National Research Council Canada | Conseil national de recherches Canada
Division of Energy | Division de l'énergie
Heat Pump Program | Programme des pompes de chaleur

An Assessment of the Potential Market Penetration of Heat Pump Waste Heat Recovery in the Canadian Photofinishing Sector

James F. Hickling Management Consultants Ltd.

September 1984

Canada

NRCC No. 25011

86-02651/

This report summarizes work carried out under contract to the Division of Energy, National Research Council of Canada. It has been published in accordance with the policy of the National Research Council of Canada of making information on energy research and development available to all interested groups. Publication by the National Research Council of Canada does not signify that the contents necessarily reflect the views or policies of the National Research Council of Canada, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. Furthermore, no warranty or representation is made with respect to the accuracy or completeness of the information contained in this report. This report is reproduced here from camera-ready copy prepared by the contractor.

Le présent rapport constitue un résumé des travaux effectués à contrat par la Division de l'énergie, Conseil national de recherches du Canada (CNRC). Sa publication est conforme à la politique du CNRC qui est de diffuser l'information disponible sur la recherche et le développement énergétiques auprès de tous les groupes intéressés. Son contenu n'exprime pas nécessairement les opinions ou politiques du Conseil national de recherches du Canada et la mention de marques ou produits commerciaux ne doit pas être considérée comme une approbation ou une recommandation d'utilisation. De plus, aucune garantie ni représentation ne peut être faite quant à l'exactitude ou à l'intégralité du contenu du rapport, qui a été reproduit à partir d'une copie prête à l'impression préparée par le sous-traitant.

Copyright 1985 by
National Research Council of Canada

Permission is granted to quote short excerpts and to reproduce figures and tables from this report, provided that the source of such material is fully acknowledged.

Copies of this and other publications of the Division of Energy may be obtained by mailing the appropriate remittance (a Bank, Express, or Post Office Money Order, or a cheque made payable to the Receiver General for Canada, credit NRC) to

Publication Sales and Distribution Office
National Research Council of Canada
Ottawa, Ontario
K1A 0R6

Price: Free

Copyright 1985 par
Conseil national de recherches du Canada

De courtes citations et la reproduction de figures et tableaux du présent rapport sont autorisées sous réserve que la source en soit clairement mentionée.

Des exemplaires du rapport et d'autres publications de la Division de l'énergie peuvent être obtenus par courrier sur le paiement d'avance des droits requis (règlement par mandat de banque, mandat-exprès, mandat-poste ou chèque payables au Receveur général du Canada, crédit du CNRC) à l'adresse suivante:

Bureau de vente et diffusion des publications
Conseil national de recherches du Canada
Ottawa (Ontario)
K1A 0R6

Prix unitaire: Gratuit

AN ASSESSMENT OF THE POTENTIAL MARKET PENETRATION OF HEAT PUMP WASTE HEAT RECOVERY IN THE CANADIAN PHOTOFINISHING SECTOR

for the

Heat Pump Program
Division of Energy Research
National Research Council Canada

prepared by
James F. Hickling Management Consultants Ltd.

Ottawa, Ontario
September, 1984
Ref. #1202

TABLE OF CONTENTS

		PAGE
1.0	**INTRODUCTION**	1
1.1	Background	1
1.1.1	Waste Heat Recovery	2
1.1.2	Investment Economics	2
1.1.3	Demonstration Site Selection	3
1.1.4	Selection of Heat Pump	5
1.2	Project Approach	6
1.2.1	Phase A - Objectives	6
1.2.2	Phase A - Practicability, Benefits and Level of Interest Within Industry	6
1.2.2.1	Task 01: Industry as a Whole	7
1.2.2.2	Task 02: Typical Plant	7
1.2.3	Phase B - Installation and Monitoring of a Demonstration Unit	8
2.0	**MARKET POTENTIAL**	9
2.1	Study Methodology	10
2.1.1	Survey Methodology	10
2.2	Survey Findings	12
2.2.1	Introduction	12
2.2.2	The Canadian Photofinishing Service Sector	13
2.2.3	Photofinishing Installation Characteristics	19
2.2.3.1	The Mini-Labs	19
2.2.3.2	Conventional Labs	20
2.2.4	Attitudes Toward Heat Pump Technology	21
2.2.4.1	Equipment Manufacturers and Distributors	21
2.2.4.2	Conventional Labs	22
2.2.4.3	Mini-Labs	23
2.2.5	The Investment and Decision-Making Process	25
2.2.5.1	Mini-Labs	25
2.2.5.2	Conventional Labs	26
2.2.6	Incentives to Promote Heat Pumps	28
2.2.7	Energy Conservation Services/Sources	29

TABLE OF CONTENTS (cont'd)

		PAGE
3.0	**TECHNICAL EVALUATION**	31
	3.1 Test Site Selection	31
	3.2 Test Site Operating Conditions	32
	3.3 Energy Audit - Building and Equipment	33
	3.3.1 Building Information	35
	3.3.2 System and Equipment Data	40
	3.4 Energy Use - 1983-84	49
4.0	**SYSTEM DESIGN AND INTEGRATION**	51
	4.1 General	51
	4.2 Concept Development	51
	4.3 Load Analysis	52
	4.4 Component Selection	52
	4.5 System Integration	53
5.0	**PRELIMINARY COST BENEFIT ANALYSIS**	54
	5.1 General	54
	5.2 Economic Model	54
	5.3 Economic Model Results	58
	5.4 Economic Viability	58
6.0	**CONCLUSIONS**	63
	APPENDIX A - Photo Lab Product Literature	65
	APPENDIX B - Letter of Interest - Snappers Photo Limited	75
	APPENDIX C - Fedders Solar Compression Furnace	79
	APPENDIX D - Survey Questionnaire - Photofinishers	89
	APPENDIX E - Survey Questionnaire - Photofinishing Equipment Suppliers	103
	APPENDIX F - Alternative Development Methodologies for the Size of the Canadian Photofinishing Sector	109
	APPENDIX G - Water Supply and Waste Water Conditioner for a Typical Operating Day at Snappers	119
	APPENDIX H - Photofinishing Sales at Snapper Photo Ltd.	125

LIST OF FIGURES

		PAGE
Figure 1 -	Heat Content of Waste Water at Snappers	34

LIST OF TABLES

	PAGE
Table 1....Target Survey Sample Distribution	11
Table 2....Actual Distribution of Survey Respondents	12
Table 3....American and Preliminary Estimate of Canadian Photoprocessing Industry	15
Table 4....Canadian Photoprocessing Sector Profile	16
Table 5....Building Occupancy Use and Environmental Conditions	39
Table 6....Operating Schedule	46
Table 7....Operating Schedule	47
Table 8....Operating Schedule	48
Table 9....Actual Gas Consumption	50
Table 10...Actual Electricity Consumption	51
Table 11...BECC VS Time at SNAPPERS Ce = $0.0713/kwh - With Load Management	60
Table 12...BECC VS Time at SNAPPERS Ce = $0.0906/kwh - at constant 12.5 kw power demand from heat pump	61
Table 13...BECC VS Time - Canadian Average Ce = $0.028/kwh - With Load Management	62
Table 14...BECC VS Time - Canadian Average Ce = $0.028/kwh - at constant 12.5 kw power demand from heat pump	62

1.0 INTRODUCTION

1.1 Background

The National Research Council, Division of Energy Research, has been seeking proposals in research and development and in the evaluation of energy conservation potential to promote market penetration of heat pumps in Canada.

The objective of the program is to support the implementation of the National Energy Program to reduce fossil fuel consumption by promoting the substitution of these fuels by centrally generated electrical energy.

Under DSS 01SX.31926-3-3051, dated January 20, 1984, proposals were sought for the novel application of heat pumps in the photofinishing service sector and, in particular, waste heat recovery applications. The general objectives of this project include:

- the evaluation of benefits to be obtained from waste heat recovery;
- the comparison of the benefits obtained from waste heat recovery identified in the photofinishing industry with those identified in parallel studies in other service industries;
- the expansion of the use of heat pumps into areas without previous operating experience;
- identification of areas where equipment development is required;

- the qualification and quantification of energy end use for a typical photofinishing plant and the entire service sector.

1.1.1 Waste Heat Recovery

There are two common approaches that offer recovery of waste heat from waste water at moderate capital cost.

The first involves the use of commercially available water-to-water heat exchangers (See Appendix A). Typical installations involve the use of plate-type heat exchangers located inline with the waste water dump from the photoprocessors. Fresh cold intake water is fed through the heat exchanger picking up heat from the waste water for use as feed water to gas-fired hot water heaters.

A second approach to waste heat recovery involves the use of heat pumps. This report details the application of heat pumps for waste heat recovery in photofinishing plants in Canada. Based on the availability of waste water and the nature of their operations, it was hypothesized that waste heat recovery in the photofinishing service sector might be viable for the use of heat pumps. Similar applications of heat pumps have been demonstrated in previous projects involving waste water heat recovery for the dry cleaning and laundering service sector.

1.1.2 Investment Economics

The major determining factor for the installation of waste heat recovery systems is system economics. Capital funds for energy conservation systems must compete with other capital projects and therefore industry requires an equal or better rate of return on investment for such projects.

1.1.3 Demonstration Site Selection

The successful outcome of any heat pump demonstration is largely determined by site specific criteria and the selection of a suitable heat pump. The approach to the selection of a site for trials is reflected in the following criteria:

i management attitudes and capabilities;

- Are they fully supportive of the application?
- What are their attitudes to energy conservation in general?
- Is there an energy management system in place?
- Do they have requisite operational and maintenance capabilities?

ii system cost and performance;

- the relationship of energy demand to system output profile affects the need for storage efficiency and cost effectiveness in the system

- ease of integrating a heat pump system into existing system

iii system maintenance;

- availability of competent service capability

iv cost savings

- local cost of energy supply
- equipment use cycles

Preliminary analysis by James F. Hickling Management Consultants Ltd. (JFH) staff of prospective photofinishing plants suggests that the system designed, developed and installed under contract for NRCC for use in a dry cleaning and laundering plant is also well suited for the typical photofinishing plant of the one-hour or same-day variety. Although component sizes would change to exactly satisfy the requirement, no preliminary design and development work would be required. Based upon these criteria, Snappers Photo Limited (Snappers) was selected for the demonstration.

Snappers furthermore expressed an interest in participating in the project (Appendix B). Snappers is a franchise operation with plants located in Toronto and New York State. The equipment used is of the one-hour variety and is representative of that available to the industry. JFH evaluated the plant site and concluded that:

- the plant is well-suited to a demonstration located in a heavily travelled area (Yonge Street, Toronto);

- there are no constraints regarding space for installation of a demonstration system;

- there is the potential for waste-heat recovery from other sources in the plant which might improve the economic benefits attributed to a heat pump installation.

1.1.4 Selection of Heat Pump

For this application the project team has selected the Fedders Carnot II Solar Compression Furnace (see Appendix C). The ability of this unit to operate efficiently at high evaporating temperatures makes it suitable for a wide variety of heat recovery applications, where heating or cooling of processed liquids is required. Such liquids can be pumped directly through the evaporator or condensor which are both equipped with copper-nickel innertubes. A variety of mildly corrosive process liquids can be handled directly without the losses associated with intermediate heat exchangers. The Fedders unit is available in four capacities, from 20,000 to 80,000 BTUs per hour nominal capacities. It is supplied complete and ready to operate when water and power lines are connected. The unit is equipped with a rotary compressor with internal overloads and counterflow coaxial condensors and evaporators. Automatic thermal expansion valves are factory installed. Contactors, relays and other components are factory wired into the control compartment. The entire assembly rests on a heavy gauge steel base with structural support members and is housed in a baked enamel steel cabinet. The Fedders unit is considered state-of-the-art because of its packaged design and the use of a rotary compressor which accounts for its remarkable operating efficiency (significantly higher COPS compared to typical reciprocating compressors).

This particular unit has been successfully demonstrated in a waste heat recovery application for the dry cleaning and laundering service sector. James F. Hickling Management Consultants Ltd. and the National Research Council have approximately seven months of operating experience using the unit. Some failures have occurred with the compressor unit, although these have been attributed to electrical overloads associated with inconsistent power supply at the plant. The problems have been subsequently resolved by Fedders and no failures have occurred in the past five months using this particular system.

1.2 Project Approach

The project is being carried out in two phases:

Phase A - Practicability, benefits and level of interest within the service sector.

Phase B - Installation and monitoring of the demonstration unit.

1.2.1 Phase A - Objectives

The prime objectives of Phase A are:

- identify the optimum size and performance of the heat pump installation
- prepare a statement of economic viability, capital cost, operating cost, benefits and payback as perceived by the plant operator,
- prepare a statement of energy savings for this plant and estimate its effect on a nation-wide basis,
- present a profile of the Canadian photofinishing service sector,
- define the investment attitudes and decision making processes of the photofinishing service sector,
- assess the potential acceptance of heat pump technology within the photofinishing service sector.

1.2.2 Phase A - Practicability, Benefits and Level of Interest Within

Phase A was performed under the following tasks:

Task 01: Industry as a Whole

Task 02: Typical Plant

1.2.2.1 Task 01: Industry as a Whole

JFH surveyed the service sector by means of telephone interviews, focus group sessions and questionnaire mailings to plant owner/operators across Canada. These owner/operators are sourced through suppliers of the equipment, association membership lists and franchisers. JFH has estimated the number of such facilities in operation in Canada, their distribution and growth rates, and categorized the plants based on their capacity. Additionally, JFH has ascertained investment attitudes, decision making processes and potential acceptance of heat pump technology. JFH's goal was a minimum of 100 responses from the entire industry.

1.2.2.2 Task 02: Typical Plant

JFH installed a data acquisition system to monitor energy end-use in the typical plant. The data acquisition system monitored the following:

- DHW delivery temperature
- cold water inlet temperature
- waste water temperature and flow rate.

The data acquisition system has been used to evaluate energy end-use for the dry cleaning and laundering service sector and to monitor the demonstration heat pump. To account for seasonal variations the monitoring of key energy loads would be performed through Phase B, should Phase B be accepted.

Since JFH developed a heat pump waste heat recovery system under contract to NRC and preliminary investigation of the planned demonstration site suggests that the basic design is fully compatible for use on this site, JFH has limited the design process to that of sizing and component selection to meet the expected higher thermal load. The storage tank would be fully compatible for this application and the heat pump evaporator stainless steel design remains uneffected by the contaminated

waste water. Should Phase B appear to be feasible, JFH will obtain a letter of interest from Snapper to formally participate in Phase B on submission of the final system configuration for the proposed demonstration site.

1.2.3 Phase B - Installation and Monitoring of a Demonstration Unit

Phase B would involve the procurement, assembly, installation and monitoring of the demonstration waste heat recovery system. This procedure follows the approach taken during other successful demonstration projects and permits best value to the Crown on the basis of needs established at the time of initiation of the demonstration. However Phase A of the study has shown that heat pump waste heat recovery is uneconomical because of the higher cost of electrical energy compared to natural gas in Toronto.

2.0 MARKET POTENTIAL

Under Task 01, JFH assessed the potential for heat pump applications in, and acceptance by, the photofinishing sector.

This section presents:

- the study methodology;
- a profile of the Canadian photofinishing service sector;
- the investment attitudes and decision-making processes within the photofinishing service sector; and
- an assessment of the potential acceptance of heat pump technology in the photofinishing service sector.

2.1 STUDY METHODOLOGY

A review of available data describing the Canadian photofinishing sector was conducted. This revealed that there is little Canadian data available. However, there are extensive and up-to-date data available fo the American photofinishing sector. To develop a profile of the Canadian photofinishing sector, the American data was adapted to reflect Canadian demographics. This "Canadianized" profile was confirmed by personal interviews of Canadian photofinishers and photofinishgin equipment suppliers.

2.1.1 Survey Methodology

The survey of Canadian photofinishers is the primary data source for this study. The photofinishing sector has two distinct sub-sectors: conventional film processors and one hour processors (mini-labs). The survey sample includes respondents from both sub-sectors. In addition, a survey of photofinishing equipment suppliers was performed to gather additional information.

The target sample size was 100 respondents, comprised of:

- equipment suppliers - 10%;
- conventional film processors - 50%; and
- mini-labs - 40%.

Table 1 presents the target sample distribution by location.

Mini-labs are beginning to emerge as part of other businesses (e.g., located in drug stores), although the majority are stand-alone operations. The sample attempted to include representation from these "imbedded" labs.

The survey questionnaire administered to the photofinishers is presented in Appendix D. Appendix E contains the survey questionnaire administered to each equipment supplier. Each photofinisher and photofinishing equipment supplier were interviewed at their respective premises.

TABLE 1
TARGET SURVEY SAMPLE DISTRIBUTION

LOCATION	EQUIPMENT SUPPLIERS	CONVENTIONAL FILM PROCESSORS	ONE HOUR LABS (MINI-LABS)
Vancouver	2	5	5
Calgary	2	5	5
Toronto	6	27	15
Ottawa	-	3	5
Montreal	-	5	5
Halifax	-	5	5
TOTAL	10	50	40

n= 100

2.2 SURVEY FINDINGS

2.2.1 Introduction

The survey was conducted in and around five major Canadian urban centres. Halifax, the sixth urban centre in the original sample design, was not surveyed due to difficulties encountered in establishing appropriate contact with photofinishers and equipment suppliers and the lack of a large conventional lab. The composition of the survey sample which was actually achieved is presented in Table 2.

TABLE 2

ACTUAL DISTRIBUTION OF SURVEY RESPONDENTS

LOCATION	EQUIPMENT SUPPLIERS	CONVENTIONAL PHOTOFINISHERS	ONE HOUR LABS (MINI-LABS)
Vancouver	0	5	2
Calgary	1	6	8
Toronto	7	24	15
Ottawa	0	4	3
Montreal	0	5	5
Halifax	0	0	0
TOTAL	8	44	23
% OF TARGET	80%	88%	58%

TOTAL RESPONSE: 75
% OF TARGET : 75%

The majority of Canadian equipment suppliers are located in the Toronto metropolitan area. Likewise, conventional photofinishers are concentrated in the Toronto area; large companies such as Black's Camera have their main laboratory in Toronto which serves all of Ontario.

The mini-lab operators were difficult to survey, since they:

- lacked a technical understanding of photofinishing processes and equipment;
- could not separate energy costs from operating costs;
- were reluctant to discuss or reveal operating or sales data; and
- were absentee owners.

As a result, the target for completed mini-lab responses was relaxed and the survey information was augmented by data from other sources, such as trade publications.

2.2.2 The Canadian Photofinishing Service Sector

Statistics Canada reports on the Canadian photographic industry under a number of SIC codes. No data is available on the photofinishing sector alone. In the United States this is not the case. The Wolfman Report on the photographic industry is published annually, and the Photo Marketing Association has recently issued a comprehensive Industry Trends Report. Both sources treat the photofinishing sector in detail.

Given the wealth of American data on the photofinishing sector and the lack of apparent differences between Canadian and American consumers, the methodology for developing a profile of the Canadian photofinishing sector is as follows:

1. create a Canadian profile from the American profile using a population ratio of 10 to 1;

2. validate/correct the profile using published Canadian figures and other known relationships between published figures and photofinishing sales; and

3. test and tune the resultant profile in interviews with suppliers to the industry and with industry representatives.

The profile from this methodology provides a directionally valid indication of the Canadian market. Table 3 presents the preliminary Canadian profile.

In 1972, a comprehensive survey of the Canadian photofinishing sector was conducted by the Canadian Photographic Magazine. This survey put the sales of the Canadian photofinishing industry at $98 million and the Gross National Photographic product* (GNPP) at $456 million. This is consistant with the approximation arrived at using the 10:1 ratio described above and shown in Table 3.

---

* Gross National Photographic Product (GNPP) is an economic measure developed by Wolfman to define the size of the U.S. photographic industry. It is the value, at retail, of all photographic equipment and materials sold in the U.S. plus the value of imports less the value of all exports of photographic equipment and related supplies.

TABLE 3: AMERICAN AND PRELIMINARY ESTIMATE OF CANADIAN PHOTOFINISHING INDUSTRY

	U.S.A.			CANADA*		
YEAR	G.N.P. ($billion)	GNPP ($million)	SALES ($ million)	G.N.P. ($billion)	GNPP ($million)	SALES ($million)
1972	1160	4800	1200	110	480	120
1979	2400	12800	2100	277	1280	210
1980	2600	14400	2300	311	1440	230**
1981	2900	15000	2400	350	1500	240
1982	-	15800	2700	302	1580	270

* GNPP and value of Photoprocessing calculated using 10% of American values; GNP are actual figures.

** McLean-Hunter Research Bureau Canada's Photography Market estimated the 1980 GNPP and photoprocessing sales volume to be one billion and approximately $150 million respectively.

A number of relationships between photofinishing sales and widely available published figures (e.g. number of households, Gross National Product (GNP) and disposable income) were used to develop a range of estimates of Canadian photofinishing expenditures. The assumptions used and the detailed application of these assumption to generate Canadian photofinishing sales is presented in Appendix F.

These assumptions provide estimates of Canadian photofinishing sales of between $230 and $280 million dollars. The 10:1 population ratio described above provided the low bound of range. Since this approximation is simple to apply and appears to provide directionally and conservative estimates of market size, it will be used to develop further characteristics of the Canadian photofinishing sector. The resulting profile is presented in Table 4.

TABLE 4
CANADIAN PHOTOFINISHING SECTOR PROFILE*

STATISTIC	COMMERCIAL LABS	MINI-LABS (ONE HOUR)	TOTAL
Number of Installations	200	300**	500
Percent of Market Share	85	15	100
Total Dollar Volume (millions)	272	48	320

* excludes "hidden" labs (OPP, RCMP, hospitals, etc...).

** may be somewhat higher (to 400). The number of small urban centers may result in a higher proportionate number of these labs than in the U.S. In Canada these labs operate as satellite labs to major centers.

SOURCE: The 1983 PMA Industry Trends Report Photographic Marketing Association, Jackson, Michigan, 1983.

Photofinishing: Quality is Number One - A State of the Industry Report, Photo-Video Retail, June/July 1984.

The equipment suppliers who were contacted concur with the estimates in Table 4. However the number of mini-labs may exceed 400 installations.

The photographic industry remained relatively stable during the recent economic recession and now appears to be growing. Photofinishing sales increased by 8.5% in 1982, with most of the growth coming from 35 mm and disc film. The industry is optimistic; some manufacturers of cameras (e.g., 35 mm rangefinders) have increased production levels to meet the projected demand. The disc camera, a new product, is currently being actively marketed. An increase in the sales of cameras and equipment would appear to indicate an increase in photofinishing sales.

A second source of optimism in the industry is the emergence of a visually literate baby boom generation who

> "are approaching a biological deadline. Now in their middle-to-late 20's and early 30's, they are feeling pressure to marry and have children. This last point should give participants in the photographic industry reason for optimism because, according to the most recent PMA Consumer Photographic Survey. Children, family and family-oriented occasions continue to constitute the largest share of picture taking opportunities." (from the 1983 PMA Industry Trends Report, Photographic Marketing association, Jackson, Michigan, 1983).

When photofinishing equipment suppliers were questioned about their projected sales in the next five years the majority did not respond. Those who did answer predicted either a stable market or steady but slow growth, with one-hour photofinishing equipment witnessing a slightly higher growth rate.

These findings from the literature review and equipment suppliers correlate with responses received from photofinishers. Of the conventional film photofinishers who responded to questions about sales growth, 36% predicted no growth in sales; 42% estimated growth at 20% or less; the remaining estimated growth at more than 20%. The mini-lab operators were reluctant to project sales growth; only 44% responded. Of these, 70% estimated sales growth between 15% and 30%, 20% estimated growth in excess of 10%, and 10% estimated no growth.

To conclude the profile of the Canadian photofinishing service sector a brief description of the market split between mini-labs and conventional labs will be presented.

Mini-labs are a new phenomenon; the first Canadian lab opened in Toronto in 1979. Since then at least 300 more have opened in Canada. Mini-labs addresss that portion of the market seeking quick "turn-around". PMA's consumer survey puts this segment of consumers at 12%, 30% of which seek quality when selecting a photoprocessor, 26% want convenience, and 24% primarily concerned with price. Currently, only 49% of mini-lab owners are equiped to provide consistant quality (e.g., have a prior background in photofinishing).

This lack of technical ability to deliver quality, combined with the comparatively low demand for quick photofinishing "turn around" will limit the market share of mini-labs to a maximum of 40% and more likely 20% of conventional consumer film processing (from Photofinishing: Quality is Number One - A State of the Industry Report, Photovideo Retail, June/July, 1984.).

In the mini-lab segment, growth appears to be in the direction of department, drug and convenience stores installing film processing units. Some main labs may extend their facilities by using mini-labs as satellite operations.

It does not appear that the large conventional labs will be forced out of business by the mini-labs. They may take a part of the "snapshot" market but will not capture the specialty processing markets. The advent and continued presence of mini-labs may force conventional labs to broaden their "horizons" by offering new services and by increasing their concentration on quality.

2.2.3 Photofinishing Installation Characteristics

Typically, the equipment used by conventional photofinishers differs from that used by the mini-labs, although conventional labs may have mini-lab processors on the premises. The equipment characteristics will be discussed separately for each type of processor.

2.2.3.1 The Mini-Labs

Currently, there are at least 11 different one-hour systems for sale in Canada. In 1979, the only one-hour system was supplied by Noritsu. They still appear to be the industry leader, with 35% of mini-lab respondents having this equipment; this is also the equipment used by the Japan Camera franchise. Japan Camera holds a large portion (215 of 300-400 Canadian mini-labs installation) of the one-hour market.

Most mini-lab installations are small (83% of respondents had only one paper and film processor) and operate six days a week between 8:00 and 16:00 hours per day.

All of the mini-lab operators surveyed rent their premises. This is consistant with the fact that they address a convenience market and, as such, must be located in high traffic areas e.g., malls. While it would be improper to extend this finding to 100% of all mini-labs, it is reasonable to assume that the vast majority of mini-labs are located on rental premises.

The mini-labs surveyed were housed in small quarters, with 63% occupying less than 93 m^2.

Few of the mini-lab operators were aware of their energy costs; 30% had their utilities included in their rent while 39% didn't have the figures available. Of those who were aware of their energy costs (7 respondents), two (2) said they were between $1000 and $1500, three (3) were between $3500 and $4000, while the remainder were greater than $6500.

None of the operators could isolate their hot water heating costs from total energy costs. None of the mini-labs used any form of energy-saving device. The majority (61%) of installations used natural gas for hot water heating with the remainder using electricity. The capacities tend to be small, with 60% of the hot water heating systems on which information was supplied (10 respondents) under 60 kW. Inlet temperatures vary from 10-20°C and, most of the photofinishing processes required hot water heated to approximately 60°C.

2.2.3.2 Conventional Labs

The conventional labs are much larger than the mini-labs; 78% of survey respondents (39 of 44 respondents) operate between one and six processors. The equipment in these labs is not standardized. In the labs surveyed, it was found that 54% of the equipment used was supplied by three companies while three additional firms supplied 15% and the balance of sites having equipment made by no less than 16 different manufacturers.

Half of the conventional labs surveyed were housed in rental premises. This subsector is more aware of utility costs, with only 30% saying that energy data was unavailable.

Energy costs make up an estimated 5% of the operating costs of a conventional lab. Of those respondents who were aware of their energy costs, 57% spent less than $15,000 on energy in 1983, 29% spent between $20,000 and $40,000, the remaining 14% spent between $45,000 and $75,000. None of the conventional lab operators could isolate the costs of supplying hot water to their photofinishing systems.

The hot water heaters and boilers installed in conventional labs are larger than those in mini-labs. Twelve of the seventeen operators (70%) which provided data had boilers up to 325 KW capacity. The largest boiler reported was rated at 965 KW capacity.

The low awareness of energy costs probably explains the low instance of energy saving devices currently in place. Only 23% of the conventional labs surveyed had installed energy saving devices.

Natural gas was confirmed as the most popular fuel among those labs surveyed; 85% use natural gas and 10% use electricity.

The labs surveyed use water with an inlet temperature between 10 and 20°C. This water is heated to between 50 and 60°C for use in photofinishing.

None of the mini-labs and only 23% of the conventional labs surveyed currently employ any energy saving devices. These energy saving devices are most commonly plate heat exchangers.

2.2.4 Attitudes Toward Heat Pump Technology

2.2.4.1 Equipment Manufacturers and Distributors

The photofinishing equipment suppliers who were interviewed indicated that energy consumption is a selling point for promoting their products. However, it does not appear to be a major selling point - minimal mention of energy saving features was made in product literature which was reviewed. The energy saving features in present equipment include preheat timers and dryer shut-offs. Energy conservation features on photofinishing equipment compete with the design objectives of minimizing chemical and water usage.

All of the equipment manufacturers and distributors surveyed were familiar with heat pump technology, although more so for residential use. Some of the suppliers were familiar with the use of heat exchangers for waste heat recovery.

Few of the suppliers were aware of the potential energy savings using heat pumps. But all of the suppliers were interested in promoting heat pump technology should it become available and prove to be economically viable for the photofinisher. They indicated that suppliers would need hard facts on energy savings available before beginning to market heat pumps. They envision heat pumps being marketed as an add-on device, or as an option on new equipment.

2.2.4.2 Conventional Labs

The conventional lab operators were the most familar with heat pump technology; 66% of the conventional labs surveyed indicated some familiarity with heat pumps. Customary sources of this knowledge were business associates and friends (33%), technical literature (26%), and heat pump manufacturers (19%). Only 38% (24) of the respondents who were aware of heat pumps felt their knowledge was "adequate" or better.

The operators who were aware of heat pumps were also aware of the energy savings which are available by using this technology. Many (45%) of the operators surveyed stated that they would install a heat pump if it proved economically viable. Major reasons given were:

- the desire to save money; and
- personal interest in energy conservation.

The operators who indicated they would not install a heat pump (15 operators, 45% of respondents) provided the following reasons:

- already have a heat exchanger or heat recovery system (33%)
- not a large enough lab in terms of volume to justify a heat pump (20%);
- felt that heat pumps would not prove economical in terms of energy savings (20%); and
- one respondent had no central water collection, and as such it would be difficult to install a heat pump.

Finally, 3 operators (10%) responded that they would consider installing a heat pump if they were provided with more information and if it could be shown to be cost effective.

When asked about the future application of heat pumps in the photofinishing sector, 79% of respondents felt that there was a good market potential. The major reason for this optimism is the businessman's objective of reducing operating costs through the recovery of waste heat from effluent water.

Five respondents (15%) indicated that there was no future for heat pumps in the photofinishing sector since heat exchangers seem well suited to waste heat recovery and are currently commercially available. The other reason for pessimism was the emergence of new photofinishing processes which make the use of hot water obsolete.

2.2.4.3 Mini-Labs

In many respects the mini-lab operators exhibited a similar attitude to heat pumps as the conventional lab operators. One-half of the mini-lab operators surveyed were aware of heat pump technology. These operators

obtained their knowledge from technical literature (41%), business associates (29%) and magazines (13%). None of the mini-lab operators had learned of heat pumps from heat pump manufacturers.

The results presented above should be interpreted carefully. Of the sample of mini-labs, only 22% are franchise installations. This is not an accurate reflection of the number of franchised mini-labs in operation. Japan Camera alone has 215 franchises while there are approximately 300-400 mini-lab installations in Canada.

For the franchised mini-lab operator, technical literature distributed by the franchise may be a source of information not accurately reflected in the survey results.

A greater percentage of mini-lab operators (50% compared to 36% conventional lab operators) felt that their knowledge of heat pump technology was at least "adequate". A majority of operators (60%) were aware of the energy savings which were possible by using a heat pump and 60% said they would install one if it proved economically feasible. Their reasons were similar to those of the conventional photofinishers. One additional reservation raised about heat pump installation was size. Mini-labs are typically housed in small quarters.

The 40% who indicated that they would not install a heat pump raised the following concerns:

- the technology is not advanced enough;
- their facility is too small and does not do enough photofinishing to justify one;
- insufficient return on investment; and
- more information is needed before making a decision.

Some mini-lab operators were optimistic about the future of heat pump technology. Of the 15 operators (65%) who responded to the question on the future of heat pump technology, 13% indicated that heat pumps have a strong future in photofinishing.

The mini-lab owners felt that locations processing large volumes of film (both mini-labs and conventional labs) would benefit from energy management. Mini-lab owners recognized that the industry is energy intensive and that as such heat recovery is a means of reducing operating costs.

2.2.5 The Investment and Decision-Making Process

This section explores the decision-making processes of the photofinishing sector, especially as it relates to energy management.

2.2.5.1 Mini-Labs

In 13 of the 15 of the mini-labs surveyed (87%), the main decision-maker is the owner. This is consistant with the fact that 70% of these labs employ fewer than 10 people.

The responsibility for analysis and comparison of various systems resides with the owner in 38% (9 of 23 respondents) of the organizations surveyed and with technical staff in 43% of organizations surveyed. In the remaining 19% of organizations, the analysis of system options is done by the equipment manufacturer.

It is possible that the franchisor's technical support staff influence the mini-lab owner's decision making process. However, the survey sample, was, again not representative of franchisees.

The major factors which influence mini-lab operator's investment decision-making are:

- capital cost/outlay;
- financial or budgetary factors (cash flow, profitability);

- return on investment/savings achieved; and
- product quality, reliability, and availability of service.

More specifically, investments in energy savings devices are evaluated by respondents against some combination of the following criteria: payback period (44%); capital cost (24%); and rate of return on investment (15%).

While few (3 of 23 respondents, or 13%) of the mini-lab operators are actively involved in energy management they do periodically review their energy consumption, and may modify their HVAC system. Energy management, however, is not a dead issue; even though few lab operators participate in energy management, 30% of mini-lab operators feel it is important and 40% consider the energy aspect in decision-making while 30% do not feel it is important.

HVAC energy saving devices do not compete for investment funds in 84% of mini-lab establishments surveyed. In the establishments where HVAC devices do compete for funds, the priority investment areas are photofinishing equipment, inventory and high return investments.

2.2.5.2 Conventional Labs

In 73% of the conventional labs surveyed, decision-making is done by owners. In the balance of the labs, decision-making is the joint responsibility of the senior management (Engineering department, production manager, plant engineer) combined with the owners. This is consistant with the lab sizes; 77% of the labs have fewer than 50 employees, while the remainder have between 60 and 500 and, hence, are more likely to have middle and senior management which would participate in decision-making.

The responsibility for analysis and comparison of various systems resides with the owner in one-third (33%) of the conventional labs surveyed, with technical staff in one-quarter (25%), with the owners and technical staff jointly in 13%. In 2 of the labs surveyed an outside engineering firm performs the analysis of system options and the equipment manufacturer either alone or in conjunction with the owner and/or technical staff in the remaining cases (23%).

Technical staff "influence" the decision making processes in 74% of the conventional labs surveyed.

The same factors influence decision-making in the conventional labs as in the mini-labs. The conventional lab owners added one item to the list which concerned the technology itself. Is the technology developing, mature or approaching obsolecence?

Investment in energy saving devices are evaluated on some combination of the following: payback period (40%), rate of return on investment (36%), capital cost (18%), lifecycle costing (4%) and cash flow (29%). Payback period appears to be the most prominent factor in evaluating energy saving devices for both types of labs. Capital cost is more important than return on investment to mini-labs.

Conventional labs are more involved in energy management than mini-labs (34% vs. 14%). Accordingly, energy management has a higher "merit level" in conventional labs; 42% of respondents judged energy management to be important; 39% considered energy management in their decision-making processes; and only 19% indicated that energy management is not important.

Of those labs involved in energy management, the following energy conservation measures have been applied:

- periodic energy use review (35%);
- revision of lighting levels (25%);
- HVAC system modification (25%);
- controls updating (10%)
- preventative HVAC maintenance (5%).

The importance of energy has not changed over the past 5 years for the majority (56%) of survey respondents. Where the importance of energy has changed, it has been in response to increased energy costs, and a desire to reduce overall operating costs. Energy saving devices must compete against photofinishing equipment for capital funds in 80% of the conventional photofinishing businesses.

2.2.6 Incentives to Promote Heat Pumps

The manufacturers and distributors of photofinishing equipment felt that the best incentive for promoting heat pump technology is a good product - one that was relatively inexpensive and delivered significant and proven energy savings. The suppliers feel that a quick payback is their best marketing tool for energy saving devices. This statement correlates well with our finding that the lab owner's primary means of assessing an investment in energy conservation is the payback period.

If the government were to offer an incentive, suppliers felt that a grant or subsidy on the purchase of a heat pump (which effectively reduces the payback period) would be most effective.

Owners of both mini-labs and conventional labs rated non-taxable grants, tax credits, technical assistance and taxable grants as the most acceptable of the incentives for promoting energy saving devices.

Commercial labs rated financial incentives higher than technical assistance. The mini-lab operators rated non-taxable grants ranking first with technical assistance second. This is attributed to the disproportionate number of independent mini-lab owners included in the sample. Generally, mini-lab owners are not technically aware, and independent mini-lab owners lack the technical support which would be available from a franchisor. Mini-labs are too small to justify in-house technical resources and as such the independent mini-lab would feel the need for technical assistance and support.

2.2.7 Energy Conservation Services/Sources

The final section of the photofinishers survey probed the lab-operator's attitudes toward heating, air conditioning and ventilation (HVAC) consultants, hardware suppliers and mechanical/electrical contractors as sources of energy conservation information.

60% mini-lab and conventional lab respondents felt that HVAC consultants were indifferent to energy saving devices. Opinion was divided equally among conventional lab owners regarding the attitude of these consultants to overall energy conservation programs; half felt these consultants were enthusiastic, and half felt they were indifferent to energy conservation programs. Mini-lab operators overwhelmingly (87%) perceived consultants to be indifferent to energy conservation programs.

The majority (60%) of lab operators perceived that hardware suppliers' attitudes toward energy saving devices to be indifferent. When asked about <u>their</u> supplier's knowledge of energy saving devices, 25% of mini-lab owners felt their supplier's knowledge to be superior while 50% of conventional lab and 40% of mini-lab operators rating their supplier's knowledge to be adequate. The balance felt the supplier's knowledge to be poor.

The opinion of mini and conventional lab operators varied on the attitudes of mechanical/electrical contractor's towards energy saving devices. Seventy percent (70%) of the mini-lab operators felt these contractors to be indifferent while only 50% of the conventional lab owners felt this to be the case. The remaining 30% and 50% of mini and conventional lab owners, respectively, felt that mechanical/electrical contractors promote the technology.

3.0 TECHNICAL EVALUATION

3.1 TEST SITE SELECTION

The project team inspected local one-hour photofinishing establishments in Ottawa for possible candidates for a demonstration site for the heat pump waste heat recovery system. Discussions with the owner/operator of these establishments established the relative similarities of one-hour/same-day photofinishing plants but more importantly confirmed that the majority of such plants are located in Metropolitan Toronto. Since it was desirable that the demonstration program impact significantly upon the industry, it was decided that a demonstration site be located in Toronto. This would ensure visibility of the technology to a significant segment of the industry where competition between operators was greatest and the benefits expected to accrue from the installation of an energy saving device would improve their competitive edge.

Subsequent to interviews held in Toronto with potential candidates, JFH selected Snappers as representative of the industry and solicited from Snappers interest in participating in the demonstration. Mr. Gordon Lewis, President of Snappers was most enthusiastic with the planned demonstration project and proposed that the plant located at 92 Yonge St. in downtown Toronto be selected for the demonstration. An inspection of the site confirmed that the plant possessed all the necessary attributes that would facilitate installation of the waste heat recovery system. These attributes included;

- highly visible location;
- access to and control of the HVAC system;
- access to and control of the hot water supply system;

- separate metering systems for the plant and other floor areas of the building;

- satisfactory customer base ensuring continued operation of the plant;

- records of all energy and water costs directly attributable to plant operation;

- supply of DHW by means of gas hot water heater, typical of most plants (60% of mini/labs and 85% of conventional labs);

- new plant making use of the most modern photofinishing equipment inclusive of silver recovery units.

3.2 TEST SITE OPERATING CONDITIONS

In order to obtain data for simulation programs and sizing of components, the plant was monitored for:

- water flow rates (from city mains);

- waste water temperature and flow rates;

- DHW delivery temperatures.

Actual testing was performed by Hovey and Associates (1979) Ltd. and JFH. Monitoring equipment was procured or adapted from previous testing carried out at the Betty Brite Demonstration Site. The results of these tests are presented in Appendix G for a typical operating day.

It is observed from the tests that:

- supply of fresh water from city mains fluctuated slightly as 15°C $\pm$ 0.5°C;

- delivery of DHW consistently remained at 58°C varying from a high of 61.5°C on start-up to a low of 57°C at end of day;

- Waste water temperature fluctuated between 30.5°C and 26°C with the weighted average at 29.5°C. Waste water flow is constant at 27.8 1/min.

Thus we may conclude that the conditions for waste heat recovery using a heat pump appear fully satisfactory. The supply of hot water to the photofinishing equipment is continuous at 40°C with nominal heat loss in the waste piping to the location of a proposed heat pump. Since the conditions are steady state rather than transient as found in laundery and dry cleaning operations the use of control valving and storage tanks from which to optimize energy recovery from the waste water are not required. The capital cost of the installed system would thus be lower than the Betty Brite Demonstration project and flow pumps would not be required with the system.

From an analysis of the test data, we can determine the heat content in the waste water based on waste water temperature and flow rate and fresh water (main) temperature and flow rate. These results are presented in Figure 1. The weighted average heat content is 29.5 kw. This rate can be effectively recovered using the Fedder's Heat Pump or other systems as may be evaluated under Phase B of the project. For the purposes of this study, waste heat recovery is accomplished using the Fedders unit because of its well documented performance capabilities.

3.3 ENERGY AUDIT - BUILDING AND EQUIPMENT

In order to complete the evaluation of the test site, JFH undertook an audit of the test site. The results of the audit are presented in the following sub-sections.

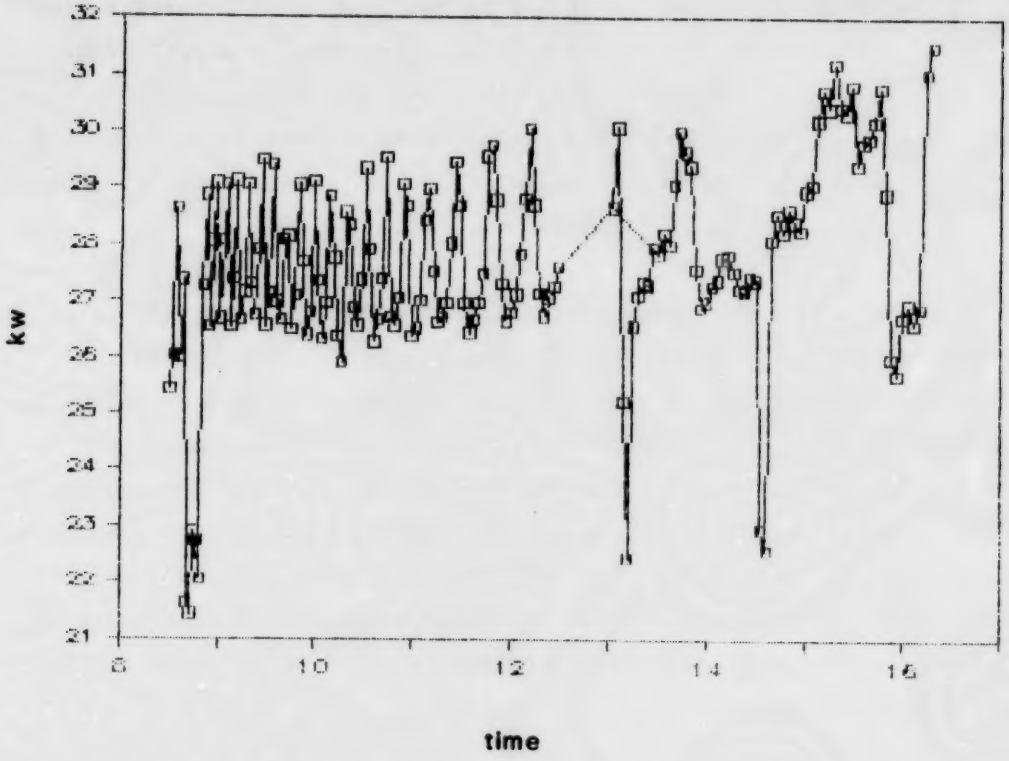


Figure 1 - Heat Content of Waste Water at Snappers

3.3.1 Building Information

a. TYPE OF BUSINESS: Snappers - One hour colour lab

ADDRESS: 92 Yonge Street
Toronto, Ontario

TYPE OF OCCUPANCY: Leased ground floor and basement

NAME OF OWNER: Wildberry Investments
591-7069
Contract - Lionel Robins or Terry Mellis

b. PHYSICAL DATA

BUILDING ORIENTATION: East-west (storefront has east exposure).

NUMBER OF FLOORS: 4 (three floors plus basement)

FLOOR AREA (GROSS): Ground Floor: 136 m^2
(65 m^2 is to be sublet)
Basement: 127 m^2

c. CONSTRUCTION TYPE

WALLS: North - Brick with 5/8" gypsum board on 5/8" x 1 5/8" wood blocking.
South - Brick with 5/8" gypsum board. First 3'3" in from store front covered with 6" x 6" ceramic tiles.
East - Brick with marine grade plywood with bonderized mat anodized aluminum, includes 3/8" glass windows.
West - Brick with 5/8" gypsom board.

WALLS FOR STORE AREA - ¼" glass sheet and 1" x ½" continuous wood member finished in plastic laminate on 5/8" gypsom board with 2" x 4" wood studs. Door to storage area 2'10" x 6'6" hollow core door plastic laminate finish and painted on stock room side. On store side plastic laminate above door.

WALLS FOR STOCKROOM - 5/8" gypsom boardd on 2" x 4" wood studs, painted finish.

ROOF: Flat, further information coming.

CEILING OF STORE - 5/8" gypsom board on metal suspension 16").C., taped, filled and sanded, painted finish.

CEILING OF STOCKROOM - Acoustic tile on metal T-bar suspension.

FLOOR OF SECOND FLOOR - further information coming.

WINDOWS: North - none
South - none
East - Ground level - 3/8" tempered glass
Second and Third floors - Each floor has three windows, approximately 3' x 6', further information coming.
West - none

Facing	% Glass/External	Total Wall Area (m^2)
North	0%	286
South	0%	286
East	42.84%	97
West	0%	97

d. GLASS SHADING:

outside - none
inside - none

e. BUILDING ENERGY: all electric and natural gas DHW

f. BUILDING OCCUPANCY AND USE: See Table 5.

NOTE: 1. Store open 8:30 a.m. to 6 p.m., Monday to Friday and 10 a.m. to 4 p.m. on Saturdays. Normally, one person arrives at 8 a.m. (Monday - Friday) to prepare for the store opening, except June 6, June 18 and June 22 when they arrived at 8:45 a.m. On Saturdays, the person arrives at 9 a.m.

2. The staff works in shifts, those coming in early to open leave early and those coming in later, stay to close. As well, one person comes in to give extra help during the afternoon (usually 12 - 5:30 p.m.).

3. The staff travels back and forth between the Yonge St. store and the Bay St. store, to drop off and pick up orders, etc.

4. On average the customers remain in the store between two and three minutes. There is a small percentage that stays between five and fifteen minutes.

5. Throughout the day the air conditioner is periodically switched off because the area near the cash gets very cool. The reason for this is the location of the thermostat. It is at the rear of the store, near the return duct and the dryer of the film processor while most of the conditioned air is introduced at the front of the store. The result is a 4.5 - 5.5°C difference in air temperature when the air conditioner is running.

Therefore there is not one indoor daytime temperature but a range of temperatures.

6. A thermometer was placed at the front of the store to determine the temperature (see Table 5). There was a 1.5 - 2.0°C difference betweeen the thermometer reading and the thermostat.

7. The air conditioning was left on over the weekend of June 12, 1984 and the evening of June 19, 1984.

g. ENVIRONMENTAL OUTDOOR CONDITIONDS: See Table 5.

h. MAINTAINED INDOOR CONDITIONS: See Table 5.

DATE	OCCUPIED BY STAFF	NUMBER OF CUSTOMERS	HOURS AIR CONDITIONED	OUTDOOR (DAY) TEMPERATURE	OUTDOOR (NIGHT) TEMPERATURE	INDOOR (DAY) TEMPERATURE	INDOOR (NIGHT) TEMPERATURE
Thursday May 31, 1984	2-4½ hrs 1-5 hrs 1-8 hrs	93	5½hrs set 21°C return fan: auto	15°C sunny	7°C	——	23°C
Saturday June 2, 1984	1-7½ hrs	18	3½ hrs set 18°C return fan: on	20°C sunny	8°C	——	25°C
Monday June 4, 1984	2-5½ hrs 2-8 hrs	177	6 hrs set 18°C return fan: auto	27°C sunny	16°C	——	24°C
Wednesday June 6, 1984	1-4 hrs 1-4½ hrs 1-8 hrs	96	6 hrs set 21°C return fan: auto on 2 hrs	29°C sunny & humid	20°C	——	27°C
Friday June 8, 1984	1-4 hrs 1-5½ hrs 1-8 hrs	97	7½ hrs set 22°C return fan: auto	29°C partial cloudy	20°C	Thermostat 22-27°C 20-26°C Thermostat	Thermostat 24°C 22°C Thermostat
Tuesday June 12, 1984	2-5 hrs 1-7 hrs 1-9½ hrs	133	5½ hrs set 22°C return fan: auto	25°C sunny	13°C	Thermostat 22-25°C 19-23°C Thermostat	Thermostat 24°C 21°C Thermostat
Thursday June 14, 1984	2-2 hrs 1-7½ hrs 1-10 hrs	92	5½ hrs set 22°C return fan: auto	17°C sunny	13°C	Thermostat 22-27°C 19-24°C Thermostat	Thermostat 25°C 25°C Thermostat
Monday June 18, 1984	1-5 hrs 2-6 hrs 1-8 hrs	180	7½ hrs set 22°C return fan: auto	30°C partial cloudy and humid	16°C	Thermostat 22°C 18°C Thermostat	Thermostat 22°C 19°C Thermostat
Wednesday June 20, 1984	1-2 hrs 1-5 hrs 2-8 hrs	99	8½ hrs set 22°C return fan: auto	20°C sunny	15°C	Thermostat 22°C 19°C Thermostat	Thermostat 22°C 19°C Thermostat
Friday June 22, 1984	2-5½ hrs 1-6 hrs 1-6½ hrs	124	5½ hrs set 22°C return fan: auto	23°C sunny	19°C	Thermostat 22-28°C 16-24°C Thermostat	Thermostat 28°C 25°C Thermostat

TABLE 5: BUILDING OCCUPANCY, USE AND ENVIRONMENTAL CONDITIONS

3.3.2 System and Equipment Data

I. HVAC SYSTEM

a. AIR HANDLING SYSTEM - Air conditioning equipment by York - 5 tons cooling capacity.

Air Handling Unit - 208/1/60 with electric heater, 10.4 kw heating capacity, 3 steps; cleanable filters, spring isolators. Unit can deliver 2100 CFM @ 0.30 external S.P. with 208/1/60 3/4 hp. motor.

Condensing Unit - Model MCE 60-25A, 208/3/60 complete with dryer, high and low pressure switch, timed-off control, low ambient kit $0^{o}F$, hot gas by pass, expansion valve kit and crank case heater.

b. INTERIOR SYSTEM DESIGNATION: Electric - forced air.

c. PRINCIPLE OF OPERATION: Intake of outside air mixed with return air from store by mixed air plenum and motorized mixing dampers. Air is then heated or cooled, depending on control setting, to correspond to thermostat setting. Conditioned air is distributed by duct work throughout store.

d. ALL FANS (SUPPLY, RETURN & EXHAUST):

EXHAUST FAN (WORK AREA) - Ceiling mounted, metal inlet grille, backdraft damper and speed control. Capacity is 150 CFM @ 0.35" S.P. At present, this fan is broken.

EXHAUST FAN (TOILET) - No information, installed by landlord.

MIXED AIR PLENUM AND MOTORIZED MIXING DAMPERS - Leak proof neoprene edged blades, opposed blade design. Set for 200 CFM outdoor air. Located above ceiling in storeroom area.

SUPPLY AIR DIFFUSERS - Louver coneface, round neck, volume control, distribution grid.
Locations - one at rear - left of store area, set for 400 CFM, one at front right of store, set for 750 CFM, one at front left of store, set for 950 CFM.

RETURN AIR GRILL - Aluminum lattice core. Located rear centre of store.

e. SOURCE OF HEATING ENERGY: Electric

f. HEATING PLANT: No boiler

g. HEATING UNITS: BASEBOARD - three forced air electric heaters, 4.0 kw capacity. Two located at front of store area - right and left sides. One located at entrance to leased space. Two electric baseboard heaters, model N27-175, 1500 W capacity located rear of space to be leased - right and left sides. Four electric baseboard heaters, mmodel N27-158, 1500 W capacity located in basement - two each side. One electric baseboard heater, model N27-158, 485 W capacity located in bathroom. One forced flow electric heater, capacity unknown, located at rear door.

UNIT HEATER - Electric duct heater, 10.4 Kw capacity, located above ceiling in storeroom area.

h. ENERGY CONSERVATION DEVICES: Not applicable

i. LIGHTING: Interior Lighting Type - Flourescent, clear white and neon.

Store Area - All three lighting types are present of 8.29 W/ft^2. (neon not included).

Storeroom - Clear white lighting of 3.09 W/ft^2.

Area To Be Leased - Clear white lighting is used. There are 0.16 W/ftY2.

Hall - Clear White lighting of 0.67 W/ft^2.

Washroom - Clear white lighting of 5.71 W/ft^2.

Basement - Clear white lighting of 0.06 W/ft^2.

NOTE - 1. Neon has no on/off switch.

2. All remaining lights have an on/off switch, some are connected to 3-way switches.

3. Both the toilet and exhaust fans are controlled by a toggle switch.

4. The return fan has an on-off-auto switch at the thermostat.

5. The condensing unit, air handling unit, film processor and film production equipment each have there own on/off breaker.

Exterior Lighting - Neon. The wattage of the neon is not yet known.

h. DOMESTIC/PROCESS HOT WATER HEATING: Two THEEM model CL-67-120-5 glass lined hot water heaters. Each has 67 gallon storage capacity with a 35 kw input using natural gas. They are set at 49°C.

II. PHOTO-PROCESSING EQUIPMENT:

a. Film Processor - Pako SLF250.(one). It requires 240 volts, 50/60 Hz, 20.5 amps, 4490 watts. It takes approximately 25 minutes to process the film. The hot water wash system is an 'on-demand' system. (The water only flows when a film is being processed). The ideal wash water rate is approximately 7 1/min. The dryer is set at 42°C and the developing chemicals are kept at 38°C.

b. Disc Processor - Pako CD-100 Disc (one). It requires 240 volts, 50/60 z, 6 amps, 1400 W. It can process a maximum of 90 disks/hour. The dry-to-dry time is 32 minutes 30 seconds. It uses wash water between 24 - 40.5°C at a rate of 0.94 1/min. The developing chemicals are kept at a temperature of 40.5°C which is tempered by water which is heated by a heater in the process and circulated by a circulation pump. In the dryer cycle the disk spins at 2000 rpm for 3 seconds and the 200 rpm for the remainder of the cycle. The dryer heater is rated at 100 W.

c. Film Production Equipment - Pako Mini Lab ML104 (one). It requires 240 volts, 40 amps. The water supply must be 4 1/min. The cooling water must be kept below 25°C. This machine must use soft water. The minimum hot water supply is 32,000 kcal/hr.

CAP101 - Microcomputer controlled, inverted, daylight-desk type printer. The exposure system is white light with a subtractive colour process.

CPP101 - Daylight-loading, roller-transport type paper processor, connected to CAP101. It operates automatically according to the supply of roll paper from CAP101. The processing speed is 8 ft/min. The developing chemicals are kept at 33°C and the dryer temperature is 50°C. The amount of hot wash water is ideally 10 l/min and cool wash water is 3-7 l/min (below 25°C). The temperature is controlled by an automatic temperature control system using thermistors. The processing tanks use individual sheathed heaters. The solutions can be preheated by a timer built into the printer. Circulation is performed automatically by chemical resistant magnet pumps. Replenishment is carried out automatically by chemical resistant micro bellows pumps. These pumps operate for one minute for one operation. The dryer is a hot air dryer.

d. Chemical Mixing Equipment - Pako Hydromixer (two). It has a polyethylene tank and is model 36-25. The mixing time is 7-10 minutes. The minimum batch is 2 gallons and the maximum batch is 11.4 gallons. The circulation pump rate (at zero lift) is 50 l/m. The transfer rate is 27 l/m at 2.9m lift. The maximum pump lift is 30m. The motor requires 115/230V, 60 Hz.

e. Refrigerator - Wood/Pako, 83 litre, model R090, type MA30A0. It requires 117V, 60 Hz, 1.5A.

f. Negative Cutter - Pako, model 4506. It requires 110 VAC, 60 Hz.

g. Electronic Cash Register - SBS, requires 117V, 50/60 Hz. 36W.

h. Electroplating Unit. For the recovery of silver from the developing chemicals. It is approximately a 16 hour batch operation requiring 25A, 12.5A are then used to hold the silver until someone shuts down the machine. It has a 1/25 hp. motor.

i. Density Meter - Macbeth, model TR924. It requires 115V, 50/60 Hz, 140W.

j. Radio - Lloyds AM/FM recorder, model VA 7854, requires 120V, 50/60 Hz, 6W.

k. Calculator - Nasco Junior 12PD.

l. Coffee Maker - Phillips 12 dial-a-brew.

III. **OPERATING SCHEDULE**: See Tables 6, 7 and 8.

GENERAL NOTES:

1. The store is only open on Saturdays for the summer (June - September).
2. Print sizes are: 35mm - 4"x6"
   126 - 4"x4"
   110 - 4"x5"
   Disk - 4"x5"
3. Chemicals are replenished at the rate of approximately 55 cm^3/min. but this varies with the processing speed, amount of chemical/area and operating time.
4. 2nd and 3rd floors are heated by the landlord, to be kept at a comfortable working temperature ($68^{\circ}F$).
5. Estimated that equipment gives off approximately 12.6 kw.
6. Timer set to turn on SLF 250, CD-100 Disc and Mini Lab ML104 at 5 a.m. to preheat and bring chemicals to temperature.
7. Also included, number of films processed per day and the number of prints made.
8. Water to the mini lab ML104 runs continuously, unless the machine is shut off.
9. Optimum operating conditions for the Mini Lab ML104 is 21°C and 50-60% relative humidity.

DATE Process Equipment	Thursday May 31, 1984	Saturday June 2, 1984	Monday June 4, 1984	Wednesday June 6, 1984	Friday June 8, 1984	Tuesday June 12, 1984	Thursday June 14, 1984	Monday June 18, 1984	Wednesday June 20, 1984	Friday June 22, 1984
Film Processor SLF 250	8 a.m.- on dryer-off 1-1:30 & after 3:30	9 a.m.- on dryer-off 2½ hrs & after 2:30	8 a.m.- on 6 p.m.-off	8:30 a.m - on 6:30 p.m.- off	8 a.m.- on 5 p.m.-off dryer off ½ hr.	8 a.m.- on 6 p.m.-off	8 a.m.- on 4:30 p.m.- off	8:30 a.m.- on 6 p.m.-off	8 a.m.- on 5 p.m.-off dryer off 1½ hrs	8:45 a.m.- on 4 p.m.-off
Disc Processor CD-100 DISC	———	9-4 p.m. kept at temp. but not used	8 a.m.- 6 p.m. 9 films processed	8:30 a.m.- on 6 p.m. - off	8 - 6 p.m. 4 disks processed	8 - 6 p.m. 4 disks processed	8 - 6 p.m. 4 disks processed	8:30 - 6 p.m. 13 disks processed	8 - 6 p.m. 3 disks processed	8:45 a.m.- 6 p.m. 2 disks processed
Film Production Equipment Mini lab MI104	8 a.m.- on 6 p.m.-off	9 a.m.- on off-2½ hrs and after 3:15 p.m.	8 a.m.- 6 p.m. off	8:30 a.m.- 6 p.m.-off	8 a.m.- on 6 p.m.-off	8 a.m.- on 6 p.m.-off	8 a.m.- on 6 p.m.-off	8:30 p.m.- 6 p.m.-off	8 a.m.- on 6 p.m.-off	8:45 a.m.- on 6 p.m.-off
Chemical Mixing Equipment	1 batch	1 batch	———	———	———	1 batch	1 batch	———	———	———
Refrigerator	continuous	continuous	continuous	continuous	continuous	continuous	continuous	continuous	continuous	continuous
Negative Cutter	negatives cut for 36 rolls of film	negatives cut for 5 rolls of film	negatives cut for 73 rolls of film	negatives cut for 26 rolls of film	negatives cut for 19 rolls of film	negatives cut for 45 rolls of films	negatives cut for 24 rolls of film	negatives cut for 62 rolls of film	negatives cut for 32 rolls of film	negatives cut for 32 rolls of film

TABLE 6: OPERATING SCHEDULE

DATE Process Equipment	Thursday May 31, 1984	Saturday June 2, 1984	Monday June 4, 1984	Wednesday June 6, 1984	Friday June 8, 1984	Tuesday June 12, 1984	Thursday June 14, 1984	Monday June 18, 1984	Wednesday June 20, 1984	Friday June 22, 1984
Cash Register	9 a.m.- on 6 p.m.-off	10a.m.- on 4 p.m.-off	9 a.m.- on 6 p.m.-off	9 a.m.- on 6 p.m.-off	8:30 a.m.- on 6 p.m.-off	8:30 a.m.- on 6 p.m.-off	9 a.m.- on 6 p.m.-off	9 a.m.- on 6 p.m.-off	8:30 a.m.- on 6 p.m.-off	9 a.m.-on 6 p.m.-off
Electroplater	1 batch	———	———	———	———	1 batch	———	———	1 batch	1 batch
Density Meter	8 a.m.- on 6 p.m.-off	9:30 a.m.- on 4 p.m.-off	8:30 a.m.- on 6 p.m.-off	9 a.m.- on 5 p.m.-off	10a.m.- on 5 p.m.-off	9 a.m.- on 5:30 p.m.- off	10:30 a.m. on 6 p.m.-off	9:30 a.m.- on 5 p.m.-off	9 a.m.- on 5 p.m.-off	10 a.m.-on 5:30 p.m.- off
Radio	used periodic-ally	———	used periodic-ally	———	used periodic-ally	used periodic-ally	used periodic-ally	———	———	———
Calculator	used periodic-ally	———	used periodic-ally	———	used periodic-ally	used periodic-ally	———	used periodic-ally	used periodic-ally	———
Coffee Maker	9 a.m.- 1 batch, kept coffee warm	———	9 a.m. - 1 batch, kept coffee warm	10 a.m.- 1 batch kept coffee warm	———	9 a.m. - 1 batch, kept coffee warm	———	9:30 a.m.- 1 batch, kept coffee warm	———	———

TABLE 7: OPERATING SCHEDULE

DATE Process Equipment	Thursday May 31, 1984	Saturday June 2, 1984	Monday June 4, 1984	Wednesday June 6, 1984	Friday June 8, 1984	Tuesday June 12, 1984	Thursday June 14, 1984	Monday June 18, 1984	Wednesday June 20, 1984	Friday June 22, 1984
Lighting - Interior Store	8 a.m.- 6 p.m. florescent light only & neon-on	9 a.m.- 4 p.m. florescent neon & 32 spot light	8 a.m.- 6 p.m. florescent neon & 8 spot light	8:30 a.m. 6 p.m. florescent neon 8:30 10:45spots	8:30 a.m.- 6 p.m. neon & 8 spots on	8:30 a.m.- 6 p.m. Florescent neon & 8 spots on	9 a.m.- 6 p.m.- florescent neon & 8 spots on	9 a.m. - 6 p.m. florescent & neon on	9 a.m. - 6 p.m. florescent neon & 8 spots on	8:45 a.m. 6 p.m.neon & 8 spots 32 spots on for 1hr
Lighting- Interior Store- room, Space to be Leased, Hall & Bathroom	8 a.m.- 6 p.m. all lights on	9 a.m. - 4 p.m. all lights on	8 a.m. - 6 p.m. all lights on	8:30 a.m.- 6 p.m. storeroom 9 a.m.rest on	8:30 a.m. 6 p.m. all lights on	8 a.m. - 6 p.m. all lights on	8:30 a.m.- 6 p.m. all lights on	8:30 a.m.- 6 p.m. all lights on	9 a.m. - 6 p.m. all lights on	9 a.m. - 6 p.m. all lights on
Lighting- Interior Basement	10 a.m.- 6 p.m. lights on	———	———	11a.m.- 2 p.m. lights on .	———	9 a.m.- 6 p.m. lights on	———	10 a.m.- 6 p.m. lights on	10 a.m.- 5 p.m. lights on	9 a.m. - 4 p.m. lights on
Lighting - Exterior	Neon always on	Neon always on	Neon always on	Neon always on	Neon always on	Neon always on	Neon always on	Neon always on	Neon always on	Neon always on
Fan-Return	auto	9 a.m. - 4 p.m.-on	auto	8:30 fan on 10:45 fan auto	auto	auto	auto	auto	auto	auto
Hot Water Flowrate SLF 250 Mini Lab ML104 W1 W2	———	4.5 1/min 5 1/min 7 1/min	5.5 1/min 4 1/min 6 1/min	5 1/min 4.5 1/min 8 1/min	8 1/min 4 1/min 7 1/min	8 1/min 5 1/min 8 1/min	6.5 1/min 4.5 1/min 6.5 1/min	7 1/min, 4.5 1/min 6.5 1/min	7 1/min 4.5 1/min 6.5 1/min	5 1/min 5 1/min 8 1/min

TABLE 8: OPERATING SCHEDULE

3.4 ENERGY USE - 1983-84

JFH was provided with gas, electricity and water bills for the plant at 92 Yonge St for a 12 month period during 1983-84. The consumption of gas and electricity is presented in Tables 9 and 10 respectively. Water consumption was confirmed at 27.8 l/min. for the plant based on the water consumption during the known billing period. The costs for gas and electricity effective September 1984 was also obtained in order to determine the economic viability of the proposed system. We observe from the gas and electricity consumption the impact of seasonal variations on energy consumption and demand for photofinishing services.

TABLE 9: NATURAL GAS CONSUMPTION AT SNAPPERS

BILLING PERIOD	CONSUMPTION M^3	CONSUMPTION $
06/05/83 - 26/05/83	241	52.98
26/05/83 - 23/06/83	906	188.58
23/06/83 - 27/07/83	986	204.61
27/07/83 - 25/08/83	229	52.91
25/08/83 - 23/09/83	884	184.17
23/09/83 - 27/10/83	541	115.44
27/10/83 - 25/11/83	385	84.17
25/11/83 - 21/12/83	547	116.64
21/12/83 - 24/01/84	881	183.57
24/01/84 - 22/02/84	864	180.16
22/02/84 - 22/03/84	830	173.17
22/03/84 - 24/04/84	867	180.38

TABLE 10: ELECTRICITY CONSUMPTION AT SNAPPERS

BILLING PERIOD	CONSUMPTION kwhr	BILLING DEMAND kw	CONSUMPTION $	DEMAND $
25/04/83-23/05/83	2400	13.8	145.41	52.30
23/05/83-22/06/83	4170	16.8	192.27	58.13
22/06/83-21/07/83	5670	17.4	222.80	60.20
21/07/83-22/08/83	4710	16.2	198.12	56.05
22/08/83-20/09/83	4920	16.8	206.15	58.13
20/09/83-20/10/83	3600	15.0	168.60	51.90
20/10/83-21/11/83	3300	15.0	162.75	51.90
21/11/83-20/12/83	2400	13.8	132.86	47.75
20/12/83-23/01/84	4470	19.2	222.27	70.87
23/01/84-21/02/84	2820	14.4	162.78	54.58
21/02/84-21/03/84	3240	15.0	176.89	56.85
21/03/84-19/04/84	3780	12.0	166.93	45.48

4.0 SYSTEM DESIGN AND INTEGRATION

4.1 GENERAL

The project team carried out preliminary engineering design of the proposed waste heat recovery system. This involved concept development, control logic, load analysis, component sizing and selection, component optimization by computer simulation, system integration and selection of suitable system controls.

Selection of the equipment used for the waste heat recovery system meets all design and regulatory requirements for Canada. The Fedders water-to-water heat pump commonly known as the solar compression furnace is UL approved and available in Canada. Available off the shelf equipment can be used thus the project team concentrated its efforts on component sizing and selection to keep the total capital cost as low as possible. This reflects the desire that the proposed waste heat recovery system be cost effective for this industry sector. An economic analysis from the view point of the plant operator is presented in Section 5.0.

4.2 CONCEPT DEVELOPMENT

Concept development of the waste heat recovery system is predicated on trial results obtained under section 3.0. The design goals are established by the project team to facilitate penetration of the system in the photoprocessing service sector. Preliminary testing has revealed that the proposed system must raise city main water from approximately 15°C to 30°C at a rate of approximately 27.8 l/min. Therefore the system must be designed so that it is capable of supplying approximately 29.5 kw. Four methods are available to do this:

- heat pump only;

- heat pump plus heat exchanger;
- heat pump plus auxillary heater;
- heat pump plus heat exchanger plus auxillary heater.

The project team selected the first option for system modeling. This option covers the method of reclaiming waste heat most appropriate for the photofinishing sector. Heat exchangers are readily available and have been proven to be cost effective. Auxillary heating systems are included as part of the hot water storage tanks. These auxillary systems are the standard gas fired hot water heaters and the heat pump installed within the system would be linked directly to the hot water heaters where these heaters act as storage tanks. The project team thus uses only one concept and optimizes component size and selection on the basis of a single concept i.e. the selection of an appropriate heat pump.

4.3 LOAD ANALYSIS

A load analysis was performed using the sample data obtained from the results of the photofinishing site investigation. Flow rates and temperatures obtained from the investigation are input into the heat pump model. The Fedder heat pump is best suited for utilization within the photoprocessing sector. System development was based on the E series heat pump of 80,000 Btuh (nominal) capacity.

4.4 COMPONENT SELECTION

All materials selected were off-the-shelf items. No component required specific design for the installation, except for piping. The heat pump was selected entirely on the basis of its heating capacity. Since the heating capacity of the heat pump proved to be fully satisfactory and the intent was to use pressurized city main water for the evaporator, no

water pump would be required at the evaporator side. For the condensor side of the heat pump however, the use of a water pump may be required in some installations, but it would appear that it is not required for the Snappers plant. The final selection of all system components would be based on availability and cost of system installation during Phase B of this project.

4.5 SYSTEM INTEGRATION

The project team carried out additional site surveys of the photofinishing plant in order to determine the optimum location for installation of a prototype waste heat recovery system proposed for use under Phase B of the project. The site surveys revealed that there was sufficient space in the basement to install a waste heat recovery system and monitoring equipment. The basement is presently used for storage and there is ample room to locate all equipment and testing apparatus. Some modification will be required for the present hot water heating line to the photofinishing system and the present drain system as well, but the remainder of currently installed plumbing remains unchanged.

5.0 PRELIMINARY COST BENEFIT ANALYSIS

5.1 GENERAL

The application of heat pump technology to waste heat recovery is receiving greater attention as an energy conservation measure. Heat rejected from industrial processes is efficiently recovered by the system for use as process heat, thus overall energy utilization is increased over conventional heat delivery systems. However, the increased efficiency increases the capital costs of the system because of the need for some modifications, additional heat exchangers, related piping controls and the heat pump itself. Although the capital cost per unit of delivered thermal energy is greater for the proposed system than for conventional electric resistance or fossil fueled hot water heating, the system operating and maintenance costs are considered lower. For economic viability the operating and maintenance cost advantage of the proposed system must generate sufficient revenue to offset the higher capital cost over time. This condition applies to add-on heat recovery systems as proposed for this application. However, for the case of new plant construction part of the added capital cost may be offset by eliminating boilers as the present primary source of process heat.

5.2 ECONOMIC MODEL

The cost-effectiveness of the proposed waste heat recovery system is determined by the market value of the useful products the system generates i.e., hot water and by the cost of owning and operating the system. In this study the conventional or reference system is a gas-fired hot water heating system with mixing valve, typically used in photofinishing plants. The breakeven capital cost, BECC, which is the cost that should not be exceeded if the venture is to be profitable, was selected as the basis for comparing the waste heat recovery system to the conventional system. The breakeven capital cost is selected for the

comparison for the following reasons:

- the approach is similar to that used by industry for making investment decisions;
- the resulting equation is general and can be used for analyzing waste heat recovery systems against any reference system, comparing each on the same basis;
- prior knowledge of the proposed system's actual capital cost is not required.

The total capital cost is obtained separately and can be frequently updated to reflect changes as detailed designs evolve. These changes do not affect the breakeven capital cost value. The breakeven capital cost is derived from the venture work method which determines the value of the venture over and above a minimum required return on investment. The value of capital investment that sets the venture worth equal to zero is known as the breakeven capital cost. A generalized breakeven capital cost economic model has been derived during the process of the Betty Brite demonstration study. Details of the model are presented in the final report.

It is key to the understanding of the results of the proposed economic model that one realizes that investments in the private sector are based on after-tax dollars, rather than pre-tax dollars as is commonly used in the public sector. Thus a break-even capital cost is particularly conservative when compared to other public sector studies of the cost benefits of heat pump systems. Revenue from the expected reduction of energy costs cannot be used in whole towards the purchase of capital goods. This revenue is directly reproducable as bottom line profit and taxed at the applicable corporate rate.

Based on the results presented in Section 2.0 which make reference to the available profit dollar for purchase of new equipment its been found that to break even the payback period that is fully acceptable to the industry is three years. Thus any system proposed here must have a return on investment which supports a payback period of less than three years. This approach thus recognizes the owner/operator's perception of the economics of introducing heat pumps into their operation. To fully substantiate the model under these conditions JFH has selected rates of return which are commonly quoted by sector representatives. In addition, Canadian taxation policy for wholly owned Canadian companies presently operating in the Province of Ontario is used for the numerical solution of the generalized economic model. Thus the following parameters apply:

- corporate tax rate - 25% (50% elsewhere in Canada);
- depreciation rate - 20%
- investment tax credit - 20%
- high risk rate of return - 12%
- discount rate - 6%
- depreciation period - 4 years
- system life - 15 years

The last factor which will affect the economic viability of the heat pump system is energy pricing. Revenue to pay for the capital cost of the system is primarily derived from energy cost savings exclusive of maintenance savings or capital replacement funds. Thus it is essential that a realistic conventional energy price scenario be utilized. Growth rates predicted by Energy, Mines and Resources are used for the economic model. In Ontario at the present time, the electrical costs as suggested by EMR, are approximately 2.5¢/kwh with natural gas costs being about 1.8¢/kwh. We thus observe however that in analyzing the results of the data that was obtained from Snappers on energy costs that the natural

gas price is indeed 1.8¢/kwh, however the cost of electricity as supplied by Toronto Hydro is well in excess of the 2.5¢/kwh generally accepted as the electrical rate for Ontario. Toronto Hydro supplies electricity on a declining cost scale based on utilization. Toronto Hydro also includes a billing demand charge which is load oriented. Thus the rate structure for electrical energy in Toronto is as follows:

- $3.79/kw;
- $0.0795/kwh for the first 100 hours;
- $0.035/kwh for the next 100 hours;
- $0.024/kwh for all remaining hours.

To complete the selection of appropriate parameters we refer to the revenue term used in the economic model. The system COP is established as 3.5. This system COP is expected using the Fedders rotary compressor for this kind of installation. Since it is desirable to ascertain the effect of the system COP on breakeven capital cost, the economic model had been tested using other COPs varying from 2.0 to 5.0. However, it is found that break even capital cost is not significantly effected by system COP. Thus the benefits which might be derived from significant technology improvements to heat pump design were assessed under this particular model and found to be generally weak. The effect of public sector incentives to industry in the form of taxable grants is often determined, however at the present time the $800 taxable grant which is available for the installation of heat pumps has not shown itself to be particularly valuable. For the purpose of this study and based on the evaluation carried out in Section 2.0 we find that the majority of photofinishers in Canada use natural gas for their hot water heating systems. Thus the system which has been used as a conventional base was a natural gas hot water heating system with system efficiencies established at .85. The economic model is then run using these particular input parameters to determine the breakeven capital cost that would be required to be met in order to satisfy the investment criteria for the photofinishing sector.

5.3 ECONOMIC MODEL RESULTS

The economic model developed under previous studies for the proposed waste heat recovery system was used to generate Tables 11 through 14. Breakeven capital cost as a function of payback period have been determined for various energy pricing scenarios. Matching these results with the estimated capital cost of the proposed system, we can obtain the respective payback periods as identified. At the present time, the capital cost per delivered kw of thermal energy for heat pump systems is of the order of $200/kw. Thus looking for a crossover at the $200/kw range we will attempt to determine the forecasted payback period.

5.4 ECONOMIC VIABILITY

The proposed waste heat recovery system is not feasible from an investment viewpoint. Based on these studies, it is observed that the payback periods for most cases exceed six to ten years.

TABLE 11: BECC VS TIME AT SNAPPERS
Ce = $0.0713/kwhr - with Load Management

YEAR	ANNUAL HOURS OF OPERATION		
	3000	2500	2000
0	0	0	0
1	-.78	-.65	-.52
2	-.2.10	-1.75	-1.40
3	-3.84	-3.20	-2.56
4	-5.93	-4.94	-3.95
5	-8.32	-6.93	-5.54
6	-10.97	-9.14	-7.31
7	-13.84	-11.54	-9.23
8	-16.93	-14.11	-11.28
9	-20.20	-16.83	-13.47
10	-23.65	-19.71	-15.76

TABLE 12: BECC VS TIME AT SNAPPERS
Ce = $0.0906/kwhr - at constant 12.5 kw power demand from heat pump

YEAR	ANNUAL HOURS OF OPERATION		
	3000	2500	2000
0	0	0	0
1	-17.70	-14.75	-11.80
2	-33.87	-28.22	-22.58
3	-48.91	-40.76	-32.61
4	-63.14	-52.62	-42.09
5	-76.77	-63.98	-51.18
6	-89.96	-74.96	-59.97
7	-102.81	-85.68	-68.54
8	-115.43	-96.19	-76.95
9	-127.87	-106.56	-85.24
10	-140.19	-116.83	-93.46

TABLE 13: BECC VS TIME - CANADIAN AVERAGE
Ce = $0.028/kwhr - With Load Management

YEAR	ANNUAL HOURS OF OPERATION		
	3000	2500	2000
0	0	0	0
1	35.89	29.91	23.92
2	65.74	54.78	43.82
3	91.034	75.86	60.68
4	112.79	93.99	75.19
5	131.75	109.79	87.83
6	148.44	123.70	98.96
7	163.29	136.07	108.86
8	176.59	147.15	117.72
9	188.58	157.15	125.72
10	199.45	166.21	132.97

TABLE 14: BECC VS TIME - CANADIAN AVERAGE
Ce = $0.028/kwhr - at constant 12.5 kw power demand from heat pump

YEAR	ANNUAL HOURS OF OPERATION		
	3000	2500	2000
0	0	0	0
1	23.93	19.94	15.95
2	43.83	36.52	29.22
3	60.69	50.57	40.46
4	75.19	62.66	50.13
5	87.83	73.19	58.56
6	98.97	82.47	65.98
7	108.86	90.72	72.57
8	117.73	98.11	78.48
9	125.72	104.77	83.81
10	132.97	110.81	88.65

The payback period of three years which is required to secure industry penetration cannot be satisfied using the heat pump waste heat recovery system. In order to investigate the reasons why the photofinishing sector heat pump application has proven to be unsuccessful economically compared to those which have been done in other sectors, we must go back to the cost of the original energy as supplied in the Toronto area. Metropolitan Toronto electrical costs are exorbitantly high. The cost of electrical energy when using the load demand of the heat pump system averages $.0713/kwh, considerably higher than the marginal cost of the electrical energy elsewhere within the province, and when no load management is used and the heat pump system demands a full 12.5 kw of electrical power, the billing demand rate causes the electrical cost to rise to $.0906/kwh. Comparing electrical cost within Metropolitan Toronto to the supply of natural gas within Metropolitan Toronto, we observe a considerable difference. We are indeed comparing costs of electricity in excess of 7¢/kwh to natural gas costs which are approximately 1.8¢/kwh. Thus as a result of the cost of electrical energy in Metropolitan Toronto we find that the installation of a waste heat recovery system using heat pumps is not economically feasible to the industry. Accumulated revenue generated by the proposed waste heat recovery system results in net loss over natural gas heating systems.

By evaluating the breakeven capital cost for the proposed waste heat recovery system using the heat pump and applying the electrical costs that are expected to occur throughout Ontario and the present cost of natural gas, we further observe that the proposed system is not economically viable within the Province of Ontario. This particular situation arises because of the fact that the conventional system used by photofinishers is natural gas and the cost of natural gas is very low compared to that of electricity. The payback periods that are generated using the lower energy costs which are associated with the natural gas and electrical costs incurred within the Province of Ontario identifies payback periods of the order of six years. This is totally unsatisfactory to the industry.

In analysing the results of the economic study and matching this with the results of the market evaluation we observe that 30% of the market of photofinishing in Canada occurs within Metropolitan Toronto alone. This indeed suggests that 30% of the market is not economically feasible in terms of installation of the waste heat recovery system using heat pumps. Clearly, we must question the validity of installing heat pumps throughout the photofinishing sector for use of waste heat recovery when the generalized economic model has suggested that the present cost of energy of conventional systems, that being of natural gas, is proven to be far more economically justifiable than the installation of energy saving devices such as heat pumps that require conversion from natural gas to electrical energy, where the cost of electrical energy is far too high compared to that of the cost of natural gas. Heat pump waste heat recovery is not a viable approach to energy management and conservation within the photofinishing sector. It is inferred from pricing scenarios proposed by various hydro utilities that, at the present time, their approach has been to sponsor significant cost savings as a result of load management over energy conservation.

The installation of heat pumps results in relatively low total energy requirements but much higher energy demand rates. These rates of the order of 10-12 kw or in smaller cases of the order of 3-5 kw will result in a penalty on the billing demand which then affects total electrical costs incurred by the photofinishing plant. On this basis any conversion to electrical energy from natural gas (or oil for that matter) when the demand for electrical energy is such that a penalty is enforced for the demand, then it would appear that such conversions to energy savings devices are not feasible at the present time.

Discussions held with representatives of Toronto Hydro have shown that the present policy of this particular utility is that electrical energy is abundant but the main problem is one of supplying energy at peak demand, thus their policy is to impose a penalty on the demand of electrical energy during peak periods and to reduce the peak demand. This particular peak demand is not alleviated by the installation of heat pumps but in fact becomes a more serious problem, although the total amount of energy required is lower.

6.0 CONCLUSIONS

The study succeeded in characterizing, quantifying and qualifying the photofinishing sector within Canada and its attitudes towards investment decisions and energy conservation issues.

It is concluded from this evaluation that the installation of heat pump waste heat recovery systems within the photofinishing sector is not economically viable at the present time. Although the industry's attitude towards energy conservation is very good and there is a significant interest within the industry for waste heat recovery systems, we observe that most photofinishers are presently operating conventional systems using natural gas heating. The relative cost differential between natural gas and electrical energy imposed by a billing demand is such that the economics of the system cannot be justified at the present time. It is therefore recommended that Phase B of the demonstration project not proceed on the basis of the economic evaluation which has been presented in this particular study. Currently, the economics are such that regardless of whether the demonstration project was successful or not, it cannot be economically justifiable and thus we do not expect to see any significant penetration of this technology into the photofinishing sector unless electrical energy costs are significantly reduced or natural gas costs rise. However, based on the evaluation of EMR's forecasts for energy costs, it is observed that the incremental increase in electrical energy costs is expected to be higher than that of natural gas i.e. 5% for electricity and 3% for natural gas. Thus, it is observed that on the basis of conventional energy supply using natural gas, photofinishers are already on the most cost-effective energy supply source available to them. Since in excess of 60% of the mini-labs and 85% of the conventional labs are on natural gas, no such conversion to electrical energy can in fact be substantiated. Of the photofinishers presently using oil fired boilers for the supply of hot water as was the

case in the dry cleaning and laundering service sector, the economics of conversion to heat pump waste heat recovery system and electrical conversion were fully substantiated with payback periods of less than three years as was demonstrated in previous studies. However, the relative economics of a heat pump waste heat recovery in photofinishing applications within Toronto proves to be unjustifiable.

Installation of a photofinishing demonstration within Toronto on the basis solely of advancement of the technology and confirmation of the energy conservation capabilities of heat pump waste heat recovery systems is not deemed sufficient. The demonstration would still fail in terms of promoting the penetration of heat pump technology into the Canadian marketplace.

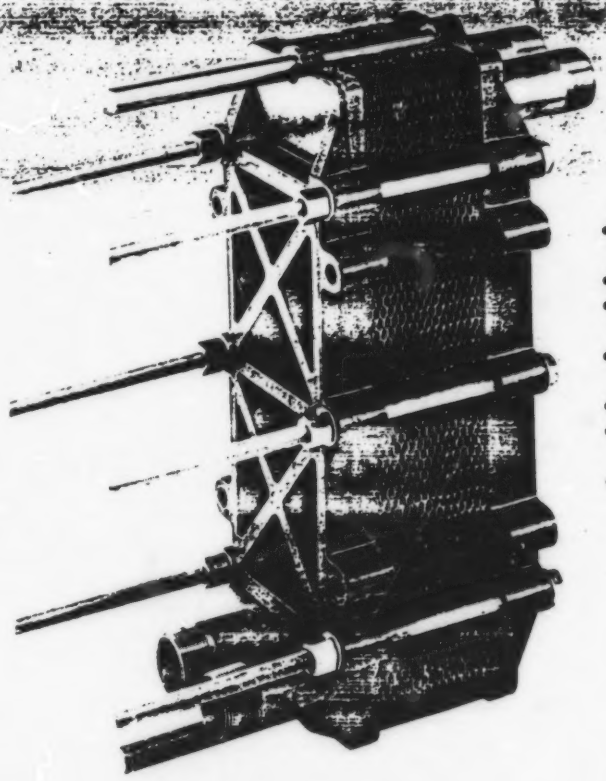
Further evaluations have also suggested that the most economical means of saving energy within the photofinishing sector is the widely available heat exchanger of the plate type. These heat exchangers are available, are economical, do provide excellent reduction in energy utilization, and are relatively inexpensive. JFH has evaluated the relative economics of using plate type heat exchangers for waste heat recovery and has found that the payback period is less than three years, and is fully justifiable for the industry. This justification is still based on the displacement of natural gas energy at low cost for waste heat recovery using the plate exchangers.

APPENDIX A

PHOTO LAB PRODUCT LITERATURE

ENERGY KING

Cut water heating costs 50% to 70%



- Expandable plate and frame heat exchanger.
- Easy to install.
- 73% to 97% heat recovery efficiency.
- Pays for itself in as few as 6 months.
- Maintenance free.
- Compact: 8"W x 14"L x 24"H (Model EK-5)
- Outperforms shell and tube heat exchangers.

DRC Products Inc

A Subsidiary of Drew Refining Company
1700 Fifth St., Berkeley, CA 94710 • (415) 527-7100 • TWX 910-366-7240
1 Hollywood Ave., Ho-Ho-Kus, NJ 07423 • (201) 652-7074 • TLX 13-0563

Energy King

an expandable plate and frame heat exchanger that guards your profits.

Reduce your water heating costs from 50% to 75%

Energy King transfers the heat from your overflow wash water to the incoming water bound for the processor. A typical installation will raise the incoming water temperature 30° without using one cent of additional energy.

Big energy savings for every processor

Mini labs, photo labs, photo processors, microfiche labs, X-ray labs, newspaper plants, lithographers . . . your processors have an appetite for hot water, but you can easily slash water heating bills in half with Energy King. Energy King is available in four cost-efficient sizes: 5 gallons per minute (GPM), 10 GPM, 25 GPM and 50 GPM. There's a size for every processor and every company.

Designed to be efficient and maintenance-free

The heat exchanger comprises a fixed frame, movable pressure plate, upper and lower carrier bars and peripheral tightening bolts. The channel plates are clamped between the frame and pressure plate using the bolts and guided by the carrier bars. The plates are corrugated to improve the heat transfer coefficient, to promote turbulance and to give the exchanger mechanical strength. These are the reasons why plate and frame heat exchangers are outperforming and replacing the conventional shell and tube design.

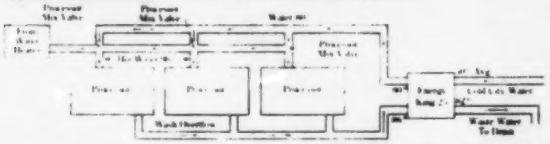
Protect your profits from skyrocketing energy costs

Why continue to heat water, discard it and heat more . . . when your profits go down the drain with every increase in energy costs? Use Energy King to turn hot waste water into a hotter bottom line.

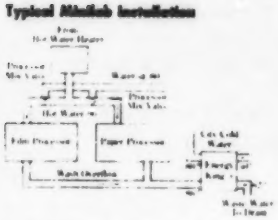
Easy to install . . . easy to expand

Before now, the replumbing necessary to install a heat exchanger often cost more than the heat recovery unit itself. Few installations were ever cost effective. However, Energy King's range of capacities and its expandable design make it easy and affordable for everyone. For instance, an Energy King 5 can be plumbed to an individual processor. This approach eliminates long pipes leading to a centralized unit, excessive heat loss and high plumbing costs. Or, where several processors exist in one area (such as in a film or paper processing department), all the processors can be plumbed to a single, larger capacity Energy King located in the department. For added flexibility, Energy King units are expandable. An Energy King 5 can be upgraded in increments of 5 GPM to an Energy King 10, 15 or 20 simply by adding plates to the existing frame. Three common installations are illustrated below.

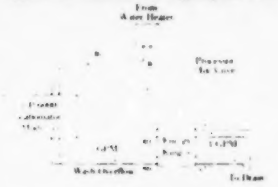
Typical Installation for Film or Paper Processing Department



Typical Minilab Installation



Typical Installation for High-Speed Processor



Energy King 5 Dimensions: 8"W x 14"L x 24"H. 96 lbs.

Flow (GPM)		Hot Temp (F°)		Cold Temp (F°)		Heat Recovered	Recovery
Hot-in	Cold-in	Hot-in	Hot-Out	Cold-in	Cold-out	BTU/HR	Efficiency
5	5	86	59.8	50	76.2	65,568	73%
5	4	86	62.5	50	79.3	58,669	81%
5	3	86	66.5	50	82.4	48,714	90%
5	2	86	72.0	50	84.9	34,936	97%

Energy King 10 Dimensions: 8"W x 28"L x 24"H. 120 lbs.

Flow (GPM)		Hot Temp (F°)		Cold Temp (F°)		Heat Recovered	Recovery
Hot-in	Cold-in	Hot-in	Hot-Out	Cold-in	Cold-out	BTU/HR	Efficiency
10	10	86	59.4	50	76.6	133,000	74%
10	9	86	60.7	50	78.1	126,669	78%
10	8	86	62.2	50	79.7	118,966	83%
10	7	86	64.1	50	81.3	109,674	95%

Energy King 25 Dimensions: 13"W x 26"L x 30"H. 300 lbs.

Flow (GPM)		Hot Temp (F°)		Cold Temp (F°)		Heat Recovered	Recovery
Hot-in	Cold-in	Hot-in	Hot-Out	Cold-in	Cold-out	BTU/HR	Efficiency
25	25	86	59.1	50	76.9	336,426	75%
25	20	86	62.0	50	80.0	300,491	83%
25	17	86	64.3	50	81.9	271,348	89%
25	15	86	66.1	50	83.0	248,113	92%

DRC Products Inc

A Subsidiary of Drew Refining Company

1700 Fifth St., Berkeley, CA 94710 • (415) 527-7100 • TWX 910-366-7240

1 Hollywood Ave., Ho-Ho-Kus, NJ 07423 • (201) 652-7074 • TLX 13-0563

STOP PAYING TO KEEP THE SEWER RATS WARM.

An Energy King heat exchanger can reduce your water heating costs 50% - 75%. Energy King transfers nearly all of the heat in your hot overflow wash water to incoming cold water bound for the processor. A typical installation will raise the incoming water temperature 30° without using one cent of additional energy. **Protect your profits from skyrocketing energy costs.** Why continue to heat water, discard it and then heat more when your profits go down the drain with every increase in energy costs? Use Energy King to turn hot waste water into a hotter bottom line. **Big energy savings for every processor.** Every mini lab, photo lab, microfiche lab, x-ray lab and printer with an appetite for hot water can easily slash water heating bills in half with Energy King. Energy King is available in four cost efficient sizes: 5 gallons per minute (GPM), 10 GPM, 25 GPM, and 50 GPM. There's a size for every processor and every company. **Slash water heating costs without tying your lab into knots.** Before now, the replumbing necessary to install a heat exchanger often cost more than the heat recovery unit itself. Few installations were ever cost effective.

However, Energy King's range of capacities and its expandable design make it easy and affordable for everyone. For instance, an Energy King 5 can be plumbed to an individual processor. This approach eliminates long pipes leading to a centralized unit which cause excessive heat loss and plumbing costs. Or, where several processors exist in one area, such as in a film or paper processing department, all the processors can be plumbed to a single, larger capacity Energy King located in the department. For added flexibility, Energy King units are expandable. An Energy King 5 can be upgraded in increments of 5 GPM to an Energy King 10, 15 or 20 simply by adding plates to the existing frame. The diagrams on the back page illustrate three common installations. **It's time to warm your pockets, not the sewer.** The first step toward protecting your lab's profits from high energy costs is to compute the cost savings and ROI potential for an Energy King installation. A convenient formula can be obtained from your DRC Products dealer. You'll see that the sooner you install Energy King, the sooner you can stop pouring profits down the drain.

Design Description

The heat exchanger comprises a fixed frame, movable pressure plate, upper and lower carrier bars and peripheral tightening bolts. The channel plates are clamped between the frame and pressure plate using the bolts and guided by the carrier bars.

The plates are corrugated to improve the heat transfer coefficient and to give the exchanger mechanical strength.

Owing to its design, the plate heat exchanger can easily be dismantled for inspection and cleaning. Moreover it can readily be extended to meet your growing requirements.

Algae can't accumulate inside Energy King because of the high water turbulence created by the patented plate design. Scaling isn't a problem either, because the temperature differential is too low for scaling to occur.

Energy King 5 Dimensions: 8" W x 14" L x 24" H, 96 lbs.

Flow (GPM)		Hot Temp (F°)		Cold Temp (F°)		Heat Recovered
Hot-in	Cold in	Hot-in	Hot-out	Cold-in	Cold-out	BTU/HR
5	5	86	59.8	50	76.2	65,568
5	4	86	62.5	50	79.3	58,669
5	3	86	66.5	50	82.4	48,714
5	2	86	72.0	50	84.9	34,936

Hot-in Flow (GPM)	Cold-in Flow (GPM)	Recovery Efficiency
5	5	73%
5	4	81%
5	3	90%
5	2	97%

Energy King 10 Dimensions: 8" W x 28" L x 24" H, 120 lbs.

Flow (GPM)		Hot Temp (F°)		Cold Temp (F°)		Heat Recovered
Hot-in	Cold in	Hot-in	Hot-out	Cold-in	Cold-out	BTU/HR
10	10	86	59.4	50	76.6	133,000
10	9	86	60.7	50	78.1	126,669
10	8	86	62.2	50	79.7	118,966
10	7	86	64.1	50	81.3	109,674

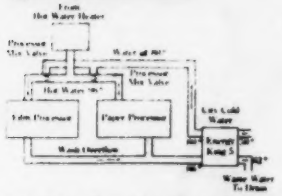
Hot-in Flow (GPM)	Cold-in Flow (GPM)	Recovery Efficiency
10	10	74%
10	9	78%
10	8	83%
10	5	95%

Energy King 25 Dimensions: 13" W x 26" x L x 30" H, 300 lbs.

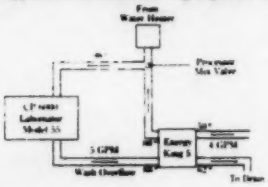
Flow (GPM)		Hot Temp (F°)		Cold Temp (F°)		Heat Recovered
Hot-in	Cold in	Hot-in	Hot-out	Cold-in	Cold-out	BTU/HR
25	25	86	59.1	50	76.9	336,428
25	20	86	62.0	50	80.0	300,491
25	17	86	64.3	50	81.9	271,348
25	15	86	66.1	50	83.0	248,113

Hot-in Flow (GPM)	Cold-in Flow (GPM)	Recovery Efficiency
25	25	75%
25	20	83%
25	17	89%
25	15	92%

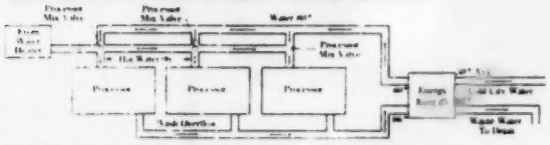
Typical MiniHub Installation



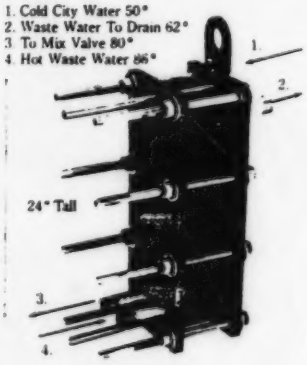
Typical Installation for High-Speed Processor



Typical Installation for Film or Paper Processing Department



1. Cold City Water 50°
2. Waste Water To Drain 62°
3. To Mix Valve 80°
4. Hot Waste Water 86°



DRC Products Inc

Unexpected Profit From Unexpected Places

Headquarters:
1717 Fourth St. Berkeley, CA 94710
(415) 527-7100 TWX 910-366-7240
Eastern:
No. 1 Hollywood Ave. HoHoKus, NJ 07423
(201) 652-7074 Telex 13-0563

Authorized Dealer

will you
HAVE SOME?

Dear Member of A.P.C.L.:

We could give you a brochure about the PACEX^{tm} WATER RECYCLING SYSTEM (and we will if you would like to have one), but we think this short letter will save you time and give you a fast and brief synopsis of exactly what the PACEX does.

If you have a need -- you SHOULD know about it.

If you don't need it ... you've spent a minimum of time and still obtained a bit of interesting knowledge.

1. The PACEX systems are available in two series; one a complete water recycling system; the other a system for removing silver from photographic wash water before it is discharged.

2. The PACEX system meets EPA requirements by virtually eliminating trace quantities of silver and thiosulfate (BOD_5).

3. Recycling wash water reduces water use by 65%. You save the cost of the water and the fee for discharging it to the sewer, as well as any sewer surcharge for pollution.

4. Saves Energy! Less fresh cold water is required when tempered water is recycled. Average saving on energy is 42%.

5. Silver recovery efficiency is excellent. Most labs lose about 10% of their available silver in the washes after hypo. The PACEX will recover about 90% of this silver.

6. The PACEX system has been field tested for more than five years and is fully patented.

May we provide you with a detailed proposal for your laboratory?

PACE International Corporation

3727 South Robertson Blvd. Culver City, California 90230 Phone: (213) 839-1188

Reducing Water Heating Costs

1717 Fourth Street
Berkeley, CA 94710
(415) 527-7100
TWX 910-366-7242

DRC ProductsIn

With spiraling energy
heating of processor wash
significant operating

Rick Tlongson

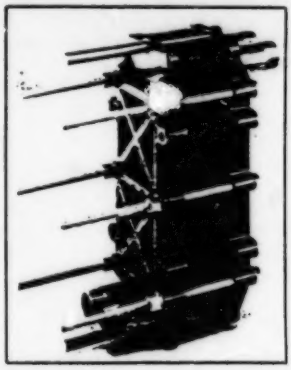
by Troy Taylor
Technical Representative
Drew Metalex Corp.

In today's economy, reduction of operating costs is more important than ever. With spiraling energy costs, heating of processor wash water is a significant factor in the overall operating cost of a photo lab. In the case of One-Hour labs, many of which are in malls and must heat water with electricity, this single cost can be a back breaker. The same can also be said of large labs, even those using gas to heat water, because processor wash water is sometimes running 24 hours a day.

With this in mind, why is it that more photo labs are not recovering heat from processor wash water? After all, a substantial amount of money was spent to heat that! Why let that money go down the drain ...especially considering how easy it is to recover the heat from that water and re-use it, which can be simply and efficiently accomplished with a HEAT EXCHANGER.

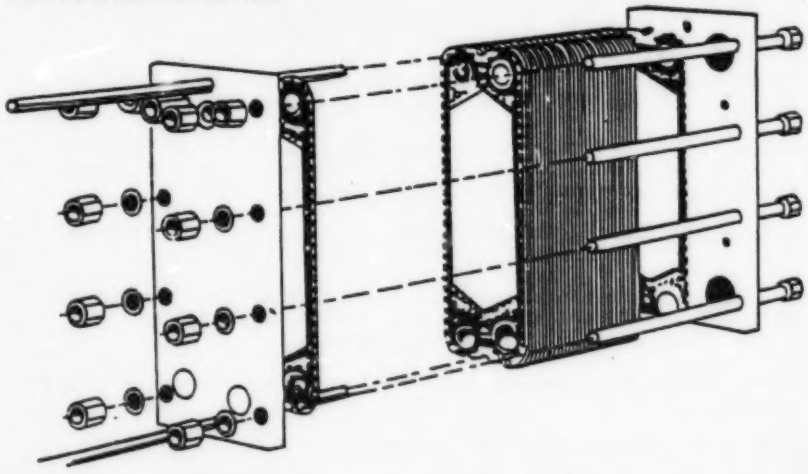
What is a Heat Exchanger?

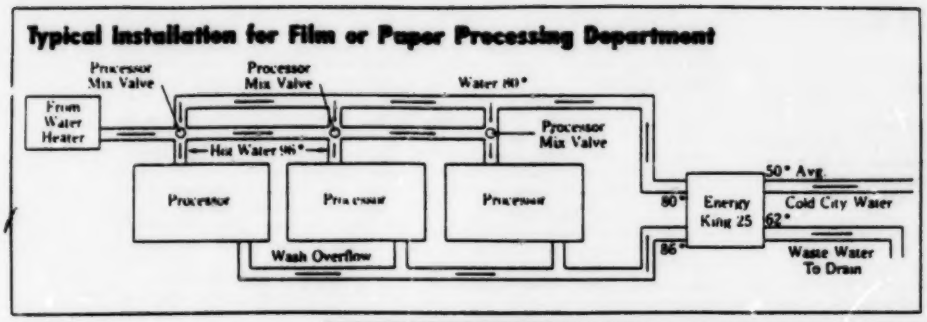
Just what the name implies...a device that has provisions for two different fluids to circulate through it in separate chambers. During this circulating, or flowing through, the fluids "exchange," or equalize, the temperatures to one extent or another. Depending on the design, size, and construction, this temperature equalization can be anywhere between 50% and 90%. This [illegible] equalization is known as the "efficiency



"Energy King," plate-and-frame heat exchanger, a DRC product.

EXPLODED DRAWING





rating."

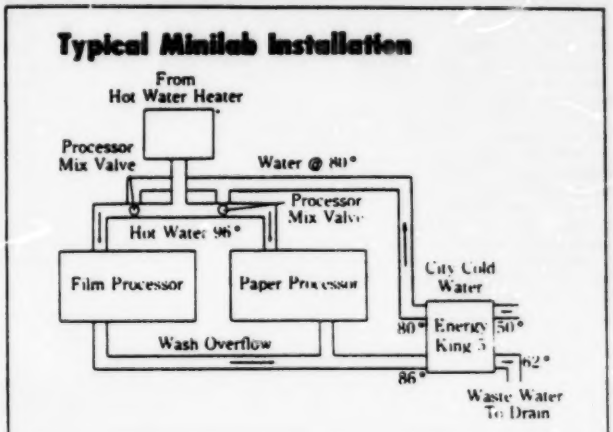
Basically, there are two types of heat exchanger designs: Plate-and-Frame and Shell-and-Tube. Due to the size, construction, materials used, and low efficiency rating, Shell-and-Tube exchangers should be ruled out for photo lab applications. Therefore, we'll concentrate on the Plate-and-Frame type.

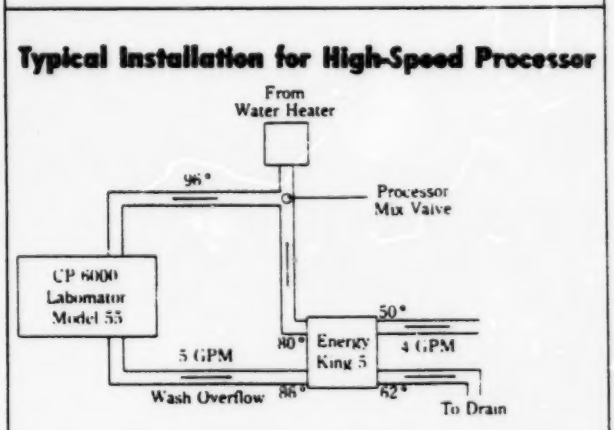
A Plate-and-Frame heat exchanger is made up of a number of thin, corrugated stainless steel plates, gasketed at the edges. This assembly of plates, known as the plate pack, is held between two heavy metal plates (the frame), causing the gasketed plates to be compressed using bolts around the outer edge of the frame. The plates have gasketed holes in the four corners, which are either open or closed, according to the flow direction wanted. Flanged, gasketed nipples extend through the frame for hook-up.

Separate Chambers

By using the closed-open-closed method of assembling the plate pack, two separate sets of chambers are created. Generally the cold city water line feeding the water heater is routed through one set of chambers, while hot waste water from the processors is pumped through the outer set of chambers in the opposite direction. Due to the gasket design and construction of the plate pack, it is impossible for the two fluids to intermix, even if a gasket fails. As the two different fluids pass through the plate pack, they change the temperatures of the plates, and therefore each other's temperature. Due to this counter-current flow pattern, the net result is that the two fluids almost equalize each other's entry temperature.

For example, if the cold *city water is* 50°F and the processor waste water is 86°F, the *cold water will exit* the heat exchanger to the water heater *at* 78°F, while the processor waste water will exit to the sewer at 60°F. This indicates heat recovery of approximately 85%.





The net effect of this heat recovery is quite simple...it takes a lot LESS ENERGY to heat water from 80°F to 140°F than from 50°F to 140°F. This

Heating Costs

from 47

results in less energy...therefore, less MONEY...being used for water heating.

Economics

In the past, only large, expensive, industrial plate heat exchangers were available. Recently, though, small, inexpensive models have become available.

Depending on the size of the lab, the number of hours operated, and the type and cost of energy, the pay-back can range anywhere from three months to two years. However, most installations will have about a one-year pay-back...except for mini labs using electric water heaters, where it's closer to a 6-month pay-back. Let's take a look at installations in two labs in Philadelphia (which have average energy costs): a one-hour lab using electrically heated water and a large photofinishing plant using gas-heated water.

One-Hour Lab

A one-hour lab open ten hours per day, seven days a week, water consumption of about 5GPM, and the processor was water is usually running six hours per day (due to water savers and intermittent use). On this basis, they would recover heat energy equal to 3,000KWH of electricity per year using a 5GPM plate-and-frame heat exchanger. At a cost of 12¢ per KWH, that is an ENERGY SAVINGS of $3,700 per year. Compared to the total cost of about $2,000 for the heat exchanger system, this gives a *pay-back of 6½ months* on energy savings alone. (There are additional savings in depreciation and energy tax credits.)

Large Finishing Lab

A large photofinishing lab operating 24 hours per day, five days a week and a water consumption of about 25GPM when all processors are running. Naturally, there are various numbers of machines running on the three shifts. Taking this into consideration, they would recover heat energy equal to 10,500 therms of natural gas per year. At a cost of 62¢ per therm, annual ENERGY SAVINGS would be $6,500. Compared to the total cost of about $4,500 for the installation, pay-back would be eight months. Again, on energy savings alone.

As mentioned before, pay-back will be affected by energy costs. As of our last survey (9/82), electric costs ranged from a low of 3¢ per KWH in Seattle to a high of 19¢ in New York. Natural gas ranged from a low of 40¢ per therm in Memphis to a high of 82¢ in Boston. Exact calculations for your area can be performed by a manufacturer or distributor of heat exchangers.

However, bear one thing in mind... energy costs are not going to go down, so what looks like a three-year pay-back today could become a one-year pay-back tomorrow.

If you would like more information on the subject of ENERGY SAVINGS, including a tabulation of data on heat recovery at various temperatures and flow rates, please contact our California or New Jersey offices (415) 527-7100 or (201) 652-7074. □

ABOUT THE AUTHOR

Troy Taylor's career in the photo industry spans over 20 years, during which time he has held positions as plant manager, quality control manager, field engineer for sensitized materials, service manager for a manufacturer of film processors and as a Tech Rep with Drew Metalex, where he specialized in silver recovery management, as well as pollution abatement, energy conservation and processor preventive maintenance programs.

REPRINTED FROM NOVEMBER, 1983, ISSUE OF PHOTOGRAPHIC PROCESSING
PRINTED IN U.S.A.

APPENDIX B

LETTER OF INTEREST - SNAPPERS PHOTO LIMITED

February 28, 1984

Mr. Frederick J. Joyce
James F. Hickling
Management Consultants Ltd.
Suite 1604
145 King Street West
Toronto, Ontario
M5H 2J3

Dear Fred:

I was very much intrigued by the discussion this morning with Mr. Varotta and yourself and have decided that the potential benefits of an energy conservation system would be worth pursuing.

As far as Phase 1 of the project is concerned, I am certain there is adequate information and data readily available to determine the energy demand and potential economy in the photographic processing industry. While Snappers represents only a small fragment of the industry in Canada we do have four labs presently in operation, relatively similar in design and size, and which could be considered prototypical of a photo processing lab. As you are aware, our total energy demand, including environmental control and water temperature elevation to processing specification is considerable relative to the size of an individual lab. I would hazard a guess that the present number of one hour labs in Canada would approach 150 and that the expansion rate is in the order of 10-15% per annum.

Before embarking on Phase 2 of the project, the Demonstration Phase, I would require a working design with specifications of the heat exchange and waste heat recovery system that is proposed for installation.

I would be prepared, as a follow-up to provide you with detailed specifications of our processing equipment, air and water heating system, air cooling system together with the quantities and cost

SUITE 600, 11 ADELAIDE ST. W.,
TORONTO, ONTARIO, CANADA M5H 1L9
TEL: (416) 362-2919

of energy consumed.

I will look forward to hearing from either yourself or Mr. Varotta with regard to the next step.

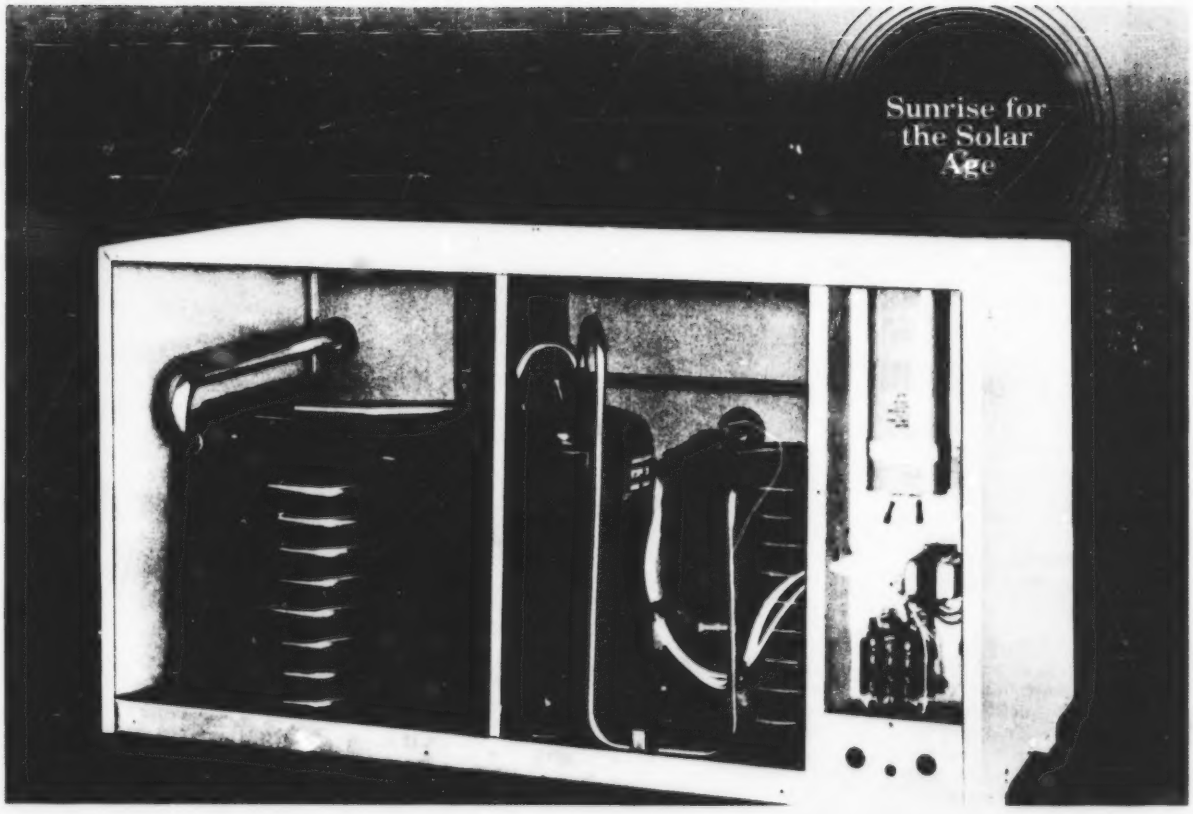
Sincerely yours,

Gordon Lewis
President

GL:cr

APPENDIX C

FEDDERS SOLAR COMPRESSION FURNACE



Here is the Fedders Carnot II Solar/Compression Furnace. It repositions solar radiation as the most cost-effective energy resource for many space and water heating systems...and offers a broad range of heat recovery applications.

Up to now, the wide variations in radiant insolation over the course of a year...and its unpredictable input over the course of a day imprisoned solar heating applications between an unrealistically high initial cost...and a disappointingly low solar fraction. The Solar Compression Furnace changes all that.

Connected in series to a solar collector-and-storage subsystem, Carnot II transforms solar heating into a technically practical, economically advantageous system for the first time. It raises solar storage temperatures between 60° F and 110° F to usable levels by a high-efficiency vapor compression system, rather than by supplementary resistance heat or fossil fuel as direct solar systems do.

Solar heated source water pumped through a coaxial counter-flow evaporator discharges heat to the refrigerant which is then raised to a higher temperature in the compressor. From there, it passes into a coaxial condenser from which it discharges high temperature water into a closed loop serving a terminal heating unit or other load. Similar equipment has been described as a "non-reversible heat pump". It should be noted, however, that in addition to lacking a reversing valve, there is no defrost requirement and no defrost controls; that the unit operates indoors and is largely independent of outdoor conditions; that no outdoor thermostatic control of supplementary heat is required.

A WIDE RANGE OF OPERATING CONDITIONS

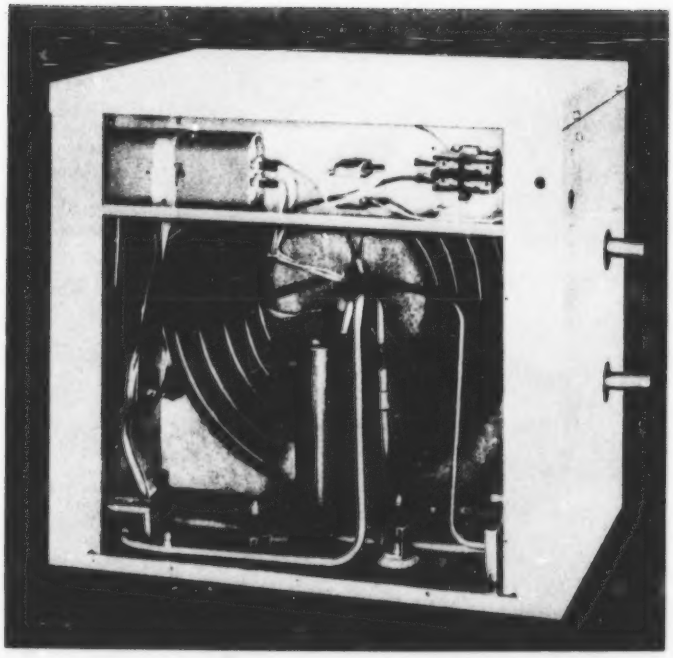
At high solar source temperatures when the Solar Compression Furnace operates at elevated evaporator temperatures, its efficiency increases. In contrast to the operation of conventional compression cycles, its watthour input actually declines. This reflects unique performance characteristics of the Carnot II's rotary compressor.

At low source temperatures, when stored energy has not been replenished due to extended overcast conditions, the Solar Compression Furnace resorts to groundwater as source energy. At an entering temperature of 55°F, groundwater from wells, ground grids or city mains permits the Solar/Compression Furnace to generate hot water with a COP of 4.2.

This defines the minimum operating efficiency of the unit and permits it to dispense completely with such back-up energy sources as resistance heat and fossil fuels which rob direct solar systems of efficiency. In systems properly sized to local levels of insolation, use of groundwater should be of brief duration and impose no significant cost penalty at this unusually high minimum efficiency. The absence of a regular energy source as a back-up will make the Solar Compression Furnace compatible to utility companies which display concern about the extra load that direct solar installations may impose during their peak operating conditions.

LOW WORKING TEMPERATURES

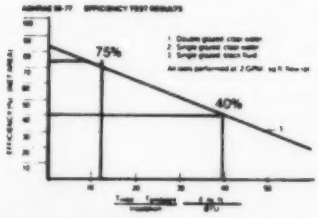
Carnot II's ability to use solar storage temperatures between 60°F and 110°F as a source without the aid of purchased thermal energy confers other important benefits on contractors and owners. Operation of solar subsystems at these low temperatures assures maximum absorption of radiant energy.



CLEAR DAY RATING Thousands of BTU per Day per Panel						
Season \ Inlet Temperature	60°	75°	110°	145°	180°	215°
WINTER Average Ambient Temperature = 20° F	29.5	19.2	10.5	4.1	0.2	0.0
SUMMER Average Ambient Temperature = 70° F	X	39.4	28.1	17.5	9.3	3.1

This is apparent in standard certified ratings for solar collectors which list daily BTU output at six entering temperatures of heat transfer material as it is pumped into the collector from storage. At inlet temperatures of 75°F and 110°F, which approximate the Solar Compression Furnace's operating range, collector output is from 100% to 300% greater than at the higher collector temperatures required by "direct" solar systems.

This advantage can be seen also in collector efficiency curves which plot a ratio of the fluid-ambient T/insolation against collector efficiency on the vertical axis. The closer incoming fluid is to outdoor winter temperatures, the more solar energy is absorbed. The difference in efficiency is inversely reflected in square feet of collector surface required; the lower the efficiency, the greater the collector area. The Solar Compression Furance can therefore reduce solar collector costs to a significant degree.



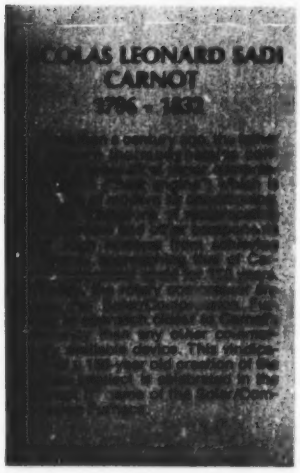
HEAT RECOVERY CAPABILITY

The ability of the Solar Compression Furnace to operate efficiently at high evaporating temperatures equips it for a wide variety of heat recovery applications. In commercial and industrial systems where waste process heat can supply a no-cost continuous supply of source energy, the

Solar Compression Furnace can make an important bottom-line contribution in business as varied as fast food restaurants and casting foundries.

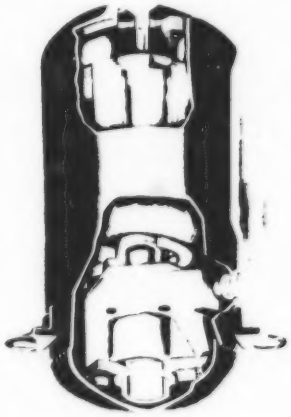
If heating or cooling of process liquids is required, such liquids can be pumped directly through the evaporator or condenser which are both equipped with cupro nickel inner tubes in all models of the compression furnace. Brines, degreasing solutions and a variety of mildly corrosive process liquids can be handled directly without the losses associated with intermediate heat exchangers.

Heat recovery with the Solar Compression Furnace can be far less costly and far more flexible in many installations where air-to-air systems are the only alternative. Massive ducts, high power blowers, heat wheels and other exchangers required in air-to-air exchange can be avoided by a ¾-inch type "L" copper pipe line and a compact Solar Compression Furnace which can be installed remotely wherever needed.



THE ROTARY COMPRESSOR

The high COP's of the Solar Compression Furnace reflects performance of its rolling piston rotary compressor. This has been confirmed by independent researchers in a Federally financed DOE contract.*



much as 40% higher for reciprocating compressors, accounts for Carnot II's remarkable operating efficiency.

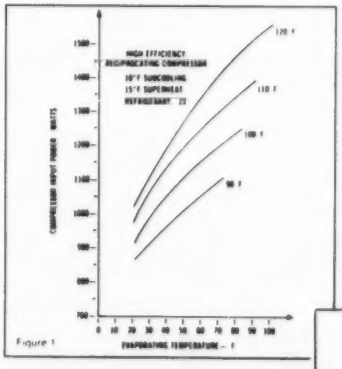


Figure 1

In the graph above, typical reciprocating compressors display a sharp increase in power input for different condensing temperatures as evaporating temperatures increase. Under identical conditions, power input for the Solar Compression Furnace's rotary compressor in the lower graph declines as evaporating temperatures increase. This difference in energy consumption which can amount to as

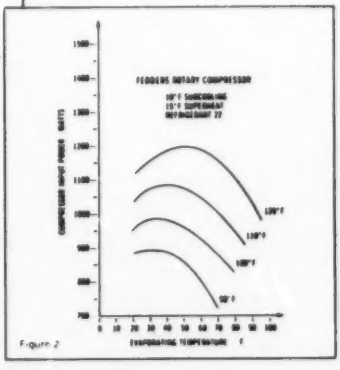


Figure 2

* Write for copy of technical paper

EQUIPMENT

The Solar Compression Carnot II Furnace is available in four capacities which are denominated in heating BTU's. They are supplied complete, ready to operate when water and power lines are connected.

They are all equipped with rotary compressors with internal overloads and counter-flow coaxial condensers and evaporators. To meet a range of operating conditions, the double wall inner tube is fabricated of corrosion resistant cupro-nickel. Automatic thermal expansion valves are factory installed. Contactors, relays and other components are factory-wired into the control compartment. The entire assembly rests on a heavy gauge steel base with structural support members and is housed in a baked enamel steel cabinet.

UNIT RATINGS

The ratings in the following tables refer only to the unit output of hot water at the indicated entering evaporator water. They do not include the significant solar fraction when collector temperatures exceed the required condensing temperature and solar radiated water moves directly to the condenser bypassing the vapor compression cycle.

STEADY STATE CAPACITY, COP EQUIPMENT RATINGS

MODEL SOCF020-700

ENTERING WATER TEMP.	LEAVING WATER TEMP. °F							
	90	100	110	120	130	140	150	160
	MBH	MBH	MBH	MBH	MBH	MBH	MBH	MBH
	COP	COP	COP	COP	COP	COP	COP	COP
FPS 4; GPM 4.4; ΔPSI 1.4 ; FT. HEAD 3.23								
55	143	133	126	119	108	103	96	92
	4.52	3.84	3.3	2.89	2.45	2.2	1.96	1.8
70	176	167	158	144	138	132	124	119
	5.31	4.52	3.89	3.24	2.87	2.56	2.23	2.03
80	198	189	180	165	159	148	143	138
	5.85	4.98	4.28	3.58	3.16	2.71	2.43	2.2
90	220	211	203	188	181	169	164	159
	6.41	5.45	4.7	3.95	3.47	2.96	2.65	2.39
100		244	227	211	205	191	185	181
		5.98	5.16	4.35	3.81	3.26	2.89	2.61
110			268	246	230	214	210	204
			6.34	4.8	4.2	3.57	3.18	2.84
120				264	260	239	234	229
				5.3	4.71	3.92	3.48	3.12
FPS 6; GPM 6.5; ΔPSI 2.7 ; FT. HEAD 6.24								
55	147	137	129	122	110	105	98	95
	4.74	3.98	3.4	2.95	2.48	2.22	1.97	1.8
70	183	174	164	158	142	136	127	122
	5.75	4.81	4.09	3.58	2.95	2.61	2.27	2.05
80	207	197	188	172	166	159	148	143
	6.45	5.39	4.58	3.77	3.3	2.91	2.49	2.24
90	232	224	213	197	190	187	170	165
	7.29	6.05	5.12	4.24	3.69	3.31	2.75	2.46
100		250	241	224	217	201	195	189
		6.78	5.73	4.78	4.13	3.48	3.06	2.72
110			271	254	247	227	220	214
			6.46	5.4	4.64	3.88	3.39	3.01
120				285	278	255	249	243
				6.00	5.21	4.33	3.8	3.35
FPS=8; GPM=8.7; ΔPSI=4.3 ; FT. HEAD = 9.93								
55	149	139	131	123	112	106	99	95
	4.89	4.08	3.46	2.99	2.5	2.24	1.98	1.81
70	187	177	167	159	145	139	129	124
	6.05	5.0	4.21	3.61	3.0	2.65	2.29	2.07
80	213	203	193	176	169	163	150	145
	6.92	5.7	4.78	3.91	3.38	2.97	2.53	2.27
90	240	230	220	203	196	189	174	168
	7.89	6.47	5.41	4.45	3.84	3.35	2.81	2.51
100		260	251	232	224	206	200	193
		7.46	6.18	5.06	4.33	3.6	3.15	2.79
110			284	264	257	234	227	221
			7.08	5.82	4.96	4.07	3.54	3.12
120				299	292	265	258	252
				6.67	5.65	4.64	4	3.51

MODEL SOCF040-700-800

ENTERING WATER TEMP.	LEAVING WATER TEMP. °F							
	90°	100°	110°	120°	130°	140°	150°	160°
	MBH	MBH	MBH	MBH	MBH	MBH	MBH	MBH
	COP	COP	COP	COP	COP	COP	COP	COP
FPS=4; GPM=8.7; ΔPSI=1.3 ; FT. HEAD 3.00								
55	319	315	309	303	296	287	277	265
	4.42	3.95	3.57	3.28	3.02	2.8	2.61	2.43
70	372	370	366	362	355	349	340	331
	4.97	4.39	3.93	3.58	3.28	3.02	2.8	2.61
80	410	408	404	402	398	391	383	375
	5.41	4.72	4.21	3.81	3.48	3.19	2.94	2.73
90	448	447	446	443	440	435	430	422
	5.91	5.12	4.53	4.06	3.69	3.38	3.11	2.88
100		490	489	488	487	483	475	472
		5.6	4.89	4.37	3.96	3.6	3.29	3.04
110			535	537	535	530	527	524
			5.33	4.74	4.25	3.84	3.5	3.23
120				585	586	581	579	573
				5.12	4.58	4.11	3.75	3.42
FPS=6; GPM=13.1; ΔPSI=2.6 ; FT. HEAD = 6.01								
55	335	331	324	318	311	302	292	279
	4.71	4.17	3.74	3.4	3.13	2.89	2.67	2.49
70	394	391	388	381	376	368	359	349
	5.43	4.72	4.18	3.76	3.43	3.14	2.9	2.68
80	434	433	429	426	422	415	406	397
	6.02	5.17	4.53	4.05	3.67	3.34	3.06	2.83
90	478	477	475	473	470	465	457	449
	6.73	5.7	4.96	4.4	3.95	3.58	3.27	3
100		526	523	523	522	517	511	504
		6.38	5.43	4.79	4.28	3.86	3.5	3.21
110			576	576	575	573	567	561
			6.05	5.27	4.65	4.18	3.78	3.44
120				630	630	628	623	619
				5.8	5.1	4.53	4.07	3.69
FPS=8; GPM=17.5; ΔPSI=4.2 ; FT. HEAD 9.70								
55	343	339	333	327	320	310	298	285
	4.87	4.29	3.83	3.47	3.18	2.93	2.71	2.51
70	404	401	397	393	387	380	370	359
	5.68	4.9	4.32	3.88	3.51	3.21	2.95	2.72
80	448	446	442	439	435	428	420	411
	6.38	5.41	4.71	4.15	3.78	3.43	3.14	2.89
90	496	494	491	488	485	480	473	465
	7.29	6.07	5.2	4.57	4.09	3.69	3.36	3.08
100		546	545	543	540	534	528	521
		6.89	5.81	5.04	4.47	4	3.61	3.3
110			602	601	596	593	585	581
			6.57	5.62	4.89	4.35	3.91	3.55
120				659	657	651	636	631
				6.29	5.44	4.76	4.24	3.83

* Instantaneous output for Solar Compression Furnace only. Does not include solar fraction.

STEADY STATE CAPACITY, COP EQUIPMENT RATINGS*

MODEL SOCF060-700/800

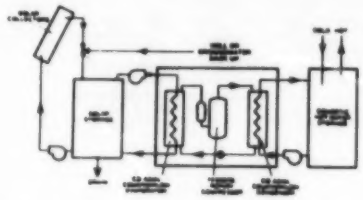
LEAVING WATER TMEP. °F								ENTERING WATER TEMP.
90	100	110	120	130	140	150	160	
MBH	MBH	MBH	MBH	MBH	MBH	MBH	MBH	
COP	*COP*	*COP*	*COP*	*COP*	*COP*	*COP*	*COP*	
FPS 4; GPM 12.7; ΔPSI .59 ; FT. HEAD 1.36								
44.1	43.6	42.9	42.1	41.1	39.9	38.4	36.8	55
4.45	*3.97*	*3.59*	*3.29*	*3.03*	*2.81*	*2.61*	*2.44*	
51.7	51.4	50.8	50.2	49.4	48.4	47.3	45.9	70
5	*4.42*	*3.95*	*3.59*	*3.29*	*3.04*	*2.81*	*2.61*	
56.9	56.6	56.2	55.9	55.2	54.3	53.3	52.2	80
5.45	*4.76*	*4.24*	*3.83*	*3.49*	*3.2*	*2.95*	*2.74*	
62.3	62.3	61.9	61.6	61.1	60.5	59.7	58.5	90
5.98	*5.18*	*4.55*	*4.09*	*3.71*	*3.4*	*3.12*	*2.88*	
	68.3	67.9	68.1	67.7	67.0	66.2	65.6	100
	5.67	*4.94*	*4.42*	*3.98*	*3.61*	*3.31*	*3.06*	
		74.7	74.5	74.2	74.0	73.3	72.6	110
		5.41	*4.76*	*4.27*	*3.87*	*3.53*	*3.24*	
			81.8	81.3	81.2	80.4	79.8	120
			5.21	*4.6*	*4.17*	*3.76*	*3.45*	
FPS 6; GPM 19.0; ΔPSI 1.77 ; FT. HEAD 4.09								
46.4	45.8	45.0	44.2	43.2	41.9	40.4	38.7	55
4.73	*4.18*	*3.75*	*3.41*	*3.14*	*2.89*	*2.68*	*2.49*	
54.6	54.2	53.5	52.9	52.1	51.1	49.9	48.5	70
5.47	*4.75*	*4.19*	*3.78*	*3.44*	*3.15*	*2.91*	*2.69*	
60.4	60.1	59.6	59.2	58.4	57.5	56.4	55.2	80
6.08	*5.22*	*4.56*	*4.07*	*3.68*	*3.35*	*3.08*	*2.84*	
66.3	66.2	66.0	65.7	65.3	64.5	63.4	62.3	90
6.81	*5.76*	*5*	*4.43*	*3.97*	*3.6*	*3.28*	*3.01*	
	73.0	72.8	72.8	72.5	71.8	71.0	69.9	100
	6.43	*5.51*	*4.85*	*4.31*	*3.88*	*3.52*	*3.22*	
		80.1	80.5	80.1	79.6	78.7	77.8	110
		6.15	*5.35*	*4.71*	*4.21*	*3.79*	*3.45*	
			87.8	87.6	87.3	86.7	85.9	120
			5.9	*5.15*	*4.58*	*4.1*	*3.71*	
FPS 8; GPM 25.4; ΔPSI 3.54 ; FT. HEAD 8.18								
47.6	47.0	46.2	45.3	44.3	43.0	41.4	39.6	55
4.9	*4.31*	*3.85*	*3.48*	*3.19*	*2.93*	*2.71*	*2.51*	
56.1	55.7	55.1	54.5	53.7	52.7	51.3	49.7	70
5.72	*4.93*	*4.34*	*3.89*	*3.53*	*3.22*	*2.95*	*2.73*	
62.1	61.8	61.3	60.9	60.3	59.4	58.3	57.0	80
6.44	*5.45*	*4.74*	*4.22*	*3.8*	*3.45*	*3.15*	*2.9*	
68.8	68.6	68.0	67.8	67.3	66.6	65.7	64.5	90
7.38	*6.13*	*5.23*	*4.6*	*4.11*	*3.71*	*3.38*	*3.09*	
	75.9	75.5	75.2	74.9	74.2	73.3	72.1	100
	6.98	*5.86*	*5.08*	*4.49*	*4.02*	*3.64*	*3.3*	
		83.5	83.3	82.9	82.3	81.5	80.7	110
		6.64	*5.66*	*4.94*	*4.39*	*3.94*	*3.57*	
			91.5	91.0	90.5	89.8	89.3	120
			6.37	*5.46*	*4.81*	*4.28*	*3.86*	

MODEL SOCF080-700/800

LEAVING WATER TEMP. °F								ENTERING WATER TEMP.
90	100	110	120	130	140	150	160	
MBH	MBH	MBH	MBH	MBH	MBH	MBH	MBH	
COP	*COP*	*COP*	*COP*	*COP*	*COP*	*COP*	*COP*	
FPS 4; GPM 17.5; ΔPSI 1.14 ; FT. HEAD 2.63								
54.5	53.8	52.8	51.8	50.6	49.2	47.5	45.5	55
4.65	*4.13*	*3.71*	*3.38*	*3.11*	*2.87*	*2.66*	*2.48*	
63.9	63.5	62.8	62.1	61.2	59.9	58.4	56.8	70
5.34	*4.66*	*4.14*	*3.73*	*3.4*	*3.12*	*2.88*	*2.67*	
70.4	70.2	69.6	69.2	68.5	67.5	66.1	64.6	80
5.89	*5.08*	*4.47*	*4.01*	*3.63*	*3.32*	*3.04*	*2.81*	
77.7	77.5	76.9	76.7	76.1	75.3	73.1	73.0	90
6.6	*5.59*	*4.86*	*4.33*	*3.9*	*3.54*	*3.24*	*2.98*	
	85.0	85.0	84.9	84.5	83.5	82.7	81.8	100
	6.21	*5.36*	*4.72*	*4.21*	*3.79*	*3.46*	*3.18*	
		93.4	93.4	93.1	92.2	91.7	90.9	110
		5.94	*5.16*	*4.58*	*4.11*	*3.72*	*3.4*	
			102.2	102.1	101.6	100.6	99.9	120
			5.7	*5*	*4.44*	*3.99*	*3.63*	
FPS 6; GPM 26.2; ΔPSI 2.28 ; FT. HEAD 5.27								
56.9	56.4	55.8	54.8	54.0	51.5	49.6	47.4	55
4.96	*4.35*	*3.88*	*3.51*	*3.2*	*2.95*	*2.72*	*2.52*	
67.1	66.7	66.1	65.3	64.4	63.1	61.5	59.6	70
5.82	*5*	*4.4*	*3.93*	*3.56*	*3.24*	*2.97*	*2.74*	
74.4	74.1	73.5	73.0	72.3	71.3	69.9	68.3	80
6.57	*5.55*	*4.81*	*4.26*	*3.83*	*3.48*	*3.17*	*2.91*	
82.4	82.2	81.5	81.3	80.7	79.9	78.8	77.4	90
7.58	*6.25*	*5.32*	*4.67*	*4.16*	*3.75*	*3.41*	*3.12*	
	91.0	90.5	90.2	89.8	89.0	88.0	86.5	100
	7.15	*5.97*	*5.16*	*4.55*	*4.07*	*3.67*	*3.33*	
		100.1	99.9	99.4	98.7	97.8	96.8	110
		6.8	*5.77*	*5.02*	*4.45*	*3.99*	*3.61*	
			109.7	109.1	108.6	107.7	107.0	120
			6.53	*5.56*	*4.88*	*4.34*	*3.91*	
FPS 8; GPM 35; ΔPSI 3.61 ; FT. HEAD 8.34								
58.3	57.6	56.6	55.4	54.2	52.6	50.7	48.5	55
5.13	*4.47*	*3.96*	*3.57*	*3.25*	*2.99*	*2.75*	*2.55*	
69.0	68.6	67.8	66.9	65.9	64.6	62.9	61.0	70
6.13	*5.22*	*4.54*	*4.03*	*3.63*	*3.3*	*3.02*	*2.78*	
76.7	76.4	75.8	75.2	74.4	73.2	71.7	70.0	80
7.03	*5.86*	*5.02*	*4.42*	*3.95*	*3.56*	*3.24*	*2.96*	
84.9	84.8	84.4	84.1	83.5	82.6	81.1	79.6	90
8.19	*6.67*	*5.63*	*4.89*	*4.33*	*3.88*	*3.5*	*3.18*	
	94.1	93.6	93.5	93.0	91.8	91.2	89.8	100
	7.74	*6.39*	*5.47*	*4.77*	*4.22*	*3.81*	*3.45*	
		103.6	103.6	103.2	102.5	101.2	99.9	110
		7.38	*6.18*	*5.33*	*4.68*	*4.14*	*3.73*	
			113.9	113.7	113.2	111.9	110.8	120
			7.08	*6*	*5.2*	*4.56*	*4.06*	

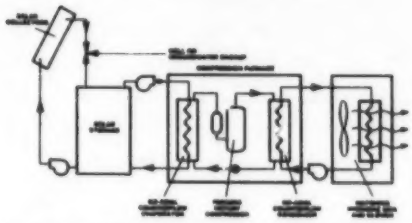
Instantaneous output for Solar Compression Furnace only Does not include solar fraction

SOLAR COMPRESSION WATER HEATER



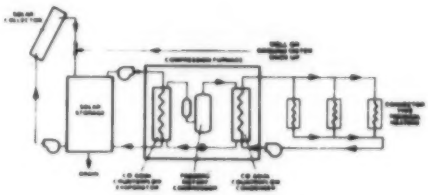
Domestic water heater utilizes solar furnace in place of heat exchanger and purchased energy to raise solar storage temperatures of 60° - 110°F to usable levels. Uses groundwater as source energy when storage temperature falls below 55°F.

SERIES-CONNECTED SOLAR COMPRESSION FURNACE



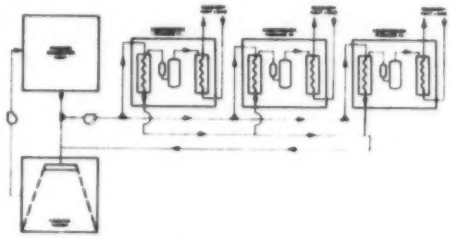
Residential heating system with fan coil in central duct plenum requires water of ≥20°F from solar furnace fed with 60° - 110°F storage water. Proper sizing of collector array and storage tanks minimizes reliance on 55°F groundwater.

SPACE HEATING WITH CONVECTION HEATING UNITS



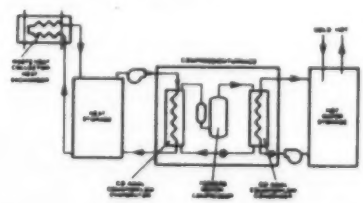
Convection-type terminal equipment (baseboard radiators, wall convectors, etc.) requiring 160° leaving water from solar furnaces, is practical retrofit for hot water central heating systems in older homes and commercial structures

LOW-COST HEAT RECOVERY FROM COOLING TOWER



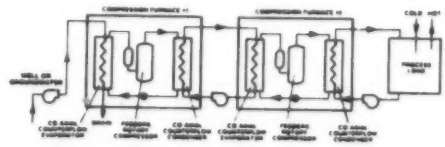
Cooling tower supply line serves as energy source for diverse remote loads without use of large costly ducts, blowers, heat exchangers, etc., required in air-to-air heat recovery systems.

WASTE HEAT RECOVERY WITH COMPRESSION FURNACE



Recapturing waste heat from exhaust hood by means of cross-flow air-to-water heat exchanger is a simple method of supplying low cost hot water for restaurants and other commercial establishments by vapor compression methods

TWO COMPRESSION FURNACES IN SERIES UTILIZING GROUND WATER



Two series-connected compression furnaces utilize groundwater as source for process heat temperatures without solar components. COP for system is higher than that of either compression furnace, although leaving water temperatures are higher, too.

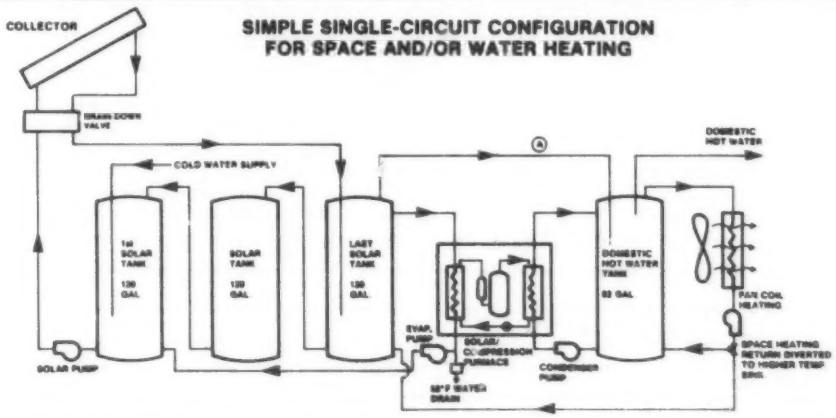
HOT WATER GENERATING CAPACITY

WATER AND/OR SPACE HEATING TEMPERATURES

Model No. Capacity @ Min. GPM	Entering Water Temp.	120°F			130°F			140°F			150°F			160°F		
		GPH	MBH	COP	GPH	MBH	COP	GPH	MBH	COP	GPH	MBH	COP	GPH	MBH	COP
	55°F	26	14.0	4.2	21	13.0	3.6	18	12.6	3.2	14	11.0	2.7	10	8.7	2.2
SOCF020	70	32	17.2	5.0	27	16.8	4.3	22	15.5	3.7	17	13.4	3.2	11	9.6	2.9
20,000 BTU	90	40	21.5	6.0	34	21.1	5.3	27	19.0	4.5	20	15.7	3.9	13	11.3	3.2
@ 2 FPS	100	45	24.2	6.7	38	23.6	5.9	30	21.1	5.2	23	18.1	4.5	15	13.1	3.7
GPM = 2.2	110				42	26.1	6.5	33	23.2	5.8	26	20.5	5.1	17	14.8	4.3
FT. HEAD = 1.043 *	120							37	26.1	6.5	29	22.8	5.7	20	17.4	4.9
	55°F	51	27.5	4.3	41	25.5	3.5	34	23.9	2.9	28	22.0	2.5	23	20.0	2.1
SOCF040	70	62	33.4	5.0	52	32.3	3.8	45	31.7	3.4	38	29.9	3.1	33	28.8	2.7
40,000 BTU	90	78	42.0	5.8	62	38.5	4.7	55	38.8	4.0	49	38.6	3.8	44	38.3	3.4
@ 2 FPS	100	90	48.5	6.8	72	44.8	5.3	59	41.6	4.3	53	41.7	4.0	47	41.0	3.7
GPM = 4.4	110				88	54.7	6.2	63	44.4	4.9	57	44.9	4.1	52	45.3	3.8
FT. HEAD = 1.006*	120							79	55.7	5.7	66	52.0	4.7	55	47.9	3.9
	55°F	70	37.7	4.4	57	35.4	3.6	47	33.1	3.0	39	30.7	2.5	32	27.9	2.1
SOCF060	70	87	46.9	5.4	74	46.0	4.2	62	43.7	3.8	53	41.7	3.2	45	39.2	2.8
60,000 BTU	90	109	58.8	6.4	88	54.7	4.9	78	55.0	4.4	67	52.8	4.0	62	54.0	3.5
@ 2 FPS	100	125	67.4	7.3	101	62.8	5.6	83	58.5	4.6	75	59.1	4.2	68	59.3	3.8
GPM = 6.4	110				117	72.8	6.6	96	67.7	5.2	80	63.0	4.3	74	64.5	4.0
FT. HEAD = 342*	120							111	78.3	6.1	93	73.3	4.9	79	68.9	4.1
	55°F	87	46.9	4.8	70	43.5	3.8	58	40.9	3.1	47	37.0	2.6	39	34.0	2.1
SOCF080	70	117	63.1	6.0	93	57.8	4.9	78	55.0	4.1	66	55.2	3.5	56	48.9	2.9
80,000 BTU	90	144	77.6	7.8	118	73.4	6.0	102	71.9	5.2	89	70.1	4.5	78	68.0	3.4
@ 2 FPS	100	165	89.0	9.7	135	84.0	7.1	113	79.7	5.6	100	78.8	4.9	89	77.6	4.3
GPM 8.8	110				155	96.4	8.6	129	91.0	6.5	109	85.9	5.3	99	86.3	4.7
FT. HEAD = 877*	120							149	105.1	8.0	126	99.3	6.2	109	95.0	5.1

Integrated ratings calculated per NSBIR-79 1951. *Pressure drop for both evaporator and condenser

SIMPLE SINGLE-CIRCUIT CONFIGURATION FOR SPACE AND/OR WATER HEATING



Unique "Sweetwater" residential space and water heating configuration is a single circuit pressurized by city main which draws cold make-up water directly into the solar storage tank as domestic hot water is used; this delivers coolest inlet water to solar panels for maximum collector efficiency. Water fed to domestic water tank via line A is same temperature as in solar storage tanks rather than 55° F; it is, therefore, raised to usable level for water/space heating by the solar furnace with minimum kw input.

When storage temperature exceeds required heating level, the solar furnace is bypassed completely. When storage temperature falls to 55° F water from city main serves as energy source.

Only controls required are drain-down valve and differential thermostat in solar loop; regular domestic tank thermostat to activate both solar furnace pumps; main heating thermostat to activate blower and pump of hydronic coil in air handler and regular thermostat in solar storage to control solenoid for 55° F water drain.

With only one storage tank and no fan coil, this configuration is an ideal domestic hot water system.

ENGINEERING SPECIFICATIONS
FEDDERS SOLAR/COMPRESSION FURNACES

MODEL NO.	SOCF 020700	SOCF 040700	SOCF 040800	SOCF 060700	SOCF 060800	SOCF 080700	SOCF 080800
HEATING							
Nominal BTUH	20,000	40,000		60,000		80,000	
At 90° F source water and 120° F leaving water	20,200	38,000		55,000		72,000	
COMPRESSOR							
Type	Rotary, Rolling Piston Compressor						
Displacement, In ³	1.61	3.22		4.44		5.30	
Refrigerant	R12	R12		R12		R12	
ELECTRICAL							
Volts	230/208	230/208	240/208	230/208	240/208	230/208	240/208
Phase, Hertz	1/60	1/60	3/60	1/60	3/60	1/60	3/60
Rated Load, Amps	5.7	14.5	9.0	17.4	11.0	21.0	14.0
Locked Rotor Amps	31.5	105.0	85.4	124.0	85.4	150.0	107.5
Min. Circuit Amps	9.2	23.3	13.6	27.0	14.9	34.0	23.0
Max. Fuse Size	20	40	30	50	30	60	40
Control Voltage	24	24	24	24	24	24	24
EVAPORATOR & CONDENSER							
Type	Tube within a Tube, Co-Axial, Counterflow						
Inner Tube Construction	Dual Wall, Cupro Nickel, Water Side, Copper, Refrigerant Side						
Diameter	3/4"	3/4"		7/8"		3/4"	
Outer Tube	Steel, Baked Enamel Finish						
Water Connection Sweat Fitting	3/4"	7/8"		1-1/8"		1-1/8"	
PRESSURE DROP							
@2FPS Velocity Ft. Head	1.043	1.006		.342		.877	
GPM	2.2	4.4		6.4		8.8	
@ 4FPS Velocity Ft. Head	3.129	3.018		1.362		2.630	
GPM	4.4	8.8		12.6		17.6	
@ 6FPS Velocity Ft. Head	6.257	6.036		4.084		5.260	
GPM	6.5	13.0		19.0		26.0	
@ 8 FPS Velocity Ft. Head	9.907	9.556		8.167		8.329	
GPM	8.7	17.4		25.2		34.8	
DIMENSIONS							
Length	24-1/8"	42-1/4"		42-1/4"		42-1/4"	
Height	22-3/8"	23-1/2"		23-1/2"		23-1/2"	
Depth	16-3/4"	19-1/2"		19-1/2"		19-1/2"	
WEIGHT							
Shipping (lbs.)	157	287		337		387	
Net (lbs.)	135	250		300		350	

Specifications subject to change without notice.

FEDDERS
SOLAR PRODUCTS COMPANY
a division of Fedders Corporation • Edison, New Jersey 08817

FSPC81601
1418180 Printed in U.S.A. 5M1180

APPENDIX D

SURVEY QUESTIONNAIRE - PHOTOFINISHERS

PHOTOFINISHER QUESTIONNAIRE

A. **Assessing market potential for future heat pump penetarion for the photoprocessing industry. Technical data to be answered as fully as possible by the respondents.**

1. **Do you own or operate the following commercial enterprises:**

   Conventional Photoprocessing ____ 1 Hour Photoprocessing ____

2. **Conventional Photoprocessing**

   How many systems _____

   What kind _____

   Volume Capacity (Roll/day) _____

   Franchise (Yes/No) _____

3. **One hour Photoprocessing**

   How many systems _____

   What kind _____

   Volume Capacity (Roll/day) _____

   Franchise (Yes/No) _____

4. **Name and address of the enterprise**

   Name _____

   Address _____

   City/Town _____ Province _____

5. **Who owns the business (at the discretion of the respondent)?**

Owner name _____ Telephone _____

Adress _____

City/Town _____ Province _____

6. **Where is the enterprise located?**

	Total Floor Area	Own	Rent
Commercial Building	_____ FT^2 (M^2)	____	____
Shopping Mall	_____ FT^2 (M^2)	____	____
Private Dwelling	_____ FT^2 (M^2)	____	____
Other (specify)	_____ FT^2 (M^2)	____	____

7. **What are the hours of operating of your photofinishing facility?**

Week days _____ hrs/day

Saturdays _____ hrs/day

Holidays & Sundays _____ hrs/day

8. **What was your total annual energy consumption? If possible complete the table.**

ENERGY	CONSUMPTION	($/MONTH)	($/YEAR)	YEAR
Electricity KWH				
Natural Gas (m^3)				
Oil (gallons)				
Other (specify)				
Total of all energy Source's used				

9. What was the cost of providing hot water for your photoprocessing equipment in 1983?

a) Conventional Photoprocessing

Single store	_____$/Year	_____$/Month
Total Enterprise	_____$/Year	_____$/Month

If you own or operate more than one photoprocessing store, list them separately.

Store No. 1	_____$/Year	_____$/Month
Store No. 2	_____$/Year	_____$/Month
Store No. 3	_____$/Year	_____$/Month
_____	_____$/Year	_____$/Month
_____	_____$/Year	_____$/Month

b) 1 Hour Photoprocessing

Single Store	_____$/Ye
Total Enterprise	_____$/Ye

If you own or operate more than one photoprocessing store, list them separately in the following manner.

Store No. 1	_____$/Year	_____$/Month
Store No. 2	_____$/Year	_____$/Month
Store No. 3	_____$/Year	_____$/Month
_____	_____$/Year	_____$/Month
_____	_____$/Year	_____$/Month

10. How do you heat your water for the photoprocessing equipment?

Electricity _____
Natural Gas _____
Oil _____
Other (specify) _____

11. Technical Data if available:

Boiler No. _____ Rating _____BBH
_____ _____
_____ _____
_____ _____
Boiler Type _____ Fuel Used _____
_____ _____
_____ _____
_____ _____

Hot Water _____°F (°C)

Supply Temp. _____°F (°C) Return Temp. _____°F (°C)

12. Do you have hot water storage systems?

_____ YES _____ NO

If "YES" specify _____ _____

Hot water, Storage Tank No. 1: Capacity _____ Gal. (Litres)
Temp. _____ °F (°C)
Flow Rate _____ Gpm (l/s)

Hot water, Storage Tank No. 2: Capacity _____ Gal. (Litres)
Temp. _____ °F (°C)
Flow Rate _____ Gpm (l/s)

13. Do you currently use any energy saving devices?

_____ YES _____ NO

If your answer is "YES" check the following:

Liquid Coupled Indirect
Heat Exchangers _____
Plate Heat Exchangers _____
Heat Pump _____
Other (specify) _____

14. Operating Data to be answered as fully as possible by the respondents:

(a) Conventional Photoprocessing

o Types of film processed	Percent of Sales	Percent of Output
35 mm	_____	_____
127	_____	_____
110	_____	_____
Other	_____	_____

- Annual sales from Processing _____$/Year
- Estimated growth in sales 1980-1984 _____
- No. of employees by location

(b) One-Hour Photoprocessing

o Types of film processed	Percent of Sales	Percent of Output
35 mm	_____	_____
127	_____	_____
110	_____	_____
Other	_____	_____

- Annual sales from Processing _____$/Year
- Estimated growth in sales 1980-1984 _____
- No. of employees by location

B. ATTITUDINAL SURVEY FOR PHOTOFINISHING FACILITY OWNERS/MANAGERS REGARDING HEAT PUMP TECHNOLOGY:

1. **Are you familiar with heat pump technology?**

____ YES ____ NO

If your answer is "YES", identify sources of your knowledge

Technical literature _____
Government Publication _____
Area Major Utility _____
Heat Pump Manufacturers _____
Business Associates _____
Other (specify) _____

2. **If "yes", what is your level of knowledge regarding these heat pumps?** Check one of the following:

well known _____
adequate _____
slight _____
not at all familiar _____

3. **Are you aware of the potential energy saving when using heat pumps?**

____ YES ____ NO

4. **If you were in a position to install a heat pump system in your photoprocessing plant what would your decision be:**

____ YES, I would use the heat pump
____ NO, I would not install the heat pump

Why? State your reasons _____

_____

_____

5. **In your opinion is there a future in Canada for the applications of heat pump technology for the photoprocessing industry?**

____ YES ____ NO

Why? State your reasons _____

_____

_____

C. ATTITUDINAL SURVEY REGARDING INVESTMENT DECISION MAKING PROCESSES. TO BE ANSWERED BY ALL RECIPIENTS OF THE QUESTIONNAIRE.

1. **Who are the main decision makers in your enterprise?** (i.e., who has the authority to approve or disapprove of the proposed investment). List their positions within the enterprise.

_____

_____

_____

2. **Who is responsible for the actual analysis and comparisons of various systems?**

technical staff _____
outside engineering firm _____
manufacturer of equipment _____
other (specify) _____

3. **What factors influence the decision making processes in your company?** List them

_____

_____

_____

4. **How do you decide the value of an investment of any energy saving device?** Check the following

		VALUE?
Rate of Return on Investment	_____	_____
Payback Period	_____	_____
Cash Flow	_____	_____
Life cycle Costing	_____	_____
Capital Cost	_____	_____
Other (specify)_____		_____

8. **Has there been any changes over the past 5 years in the company that may have affected the relative importance of energy management programs?**

____ YES ____ NO

If your answer is "YES", what are they?

	improved	reduced
Economic factors	___	___
Government Policies	___	___
Other (specify) _____	___	___

9. **Do investments in HVAC energy saving devices compete for funds in other investment areas of your company?**

_____YES _____NO

If your answer is "YES", list the priority investments

_____

_____

_____

10. **What type of incentives would you accept if government were to promote the installation of certain energy saving devices?** Check the appropriate answers.

Taxable grants	_____
Non-Taxable grants	_____
Tax Credits	_____
Tax Changes	_____
Free technical advice and support	_____
Subsidy programs	_____
Other (specify)	_____
None	_____

D. SERVICES PROVIDED

11. **In your opinion, what are the attitudes of heating, ventilation and air conditioning consultants towards energy savings devices?**

promote the technology _____
indifferent _____
discourage the conversion
to energy saving devices _____
don't know _____

12. **How would you rate the attitudes of these consultants to overall energy conservation programs?**

enthusiastic _____
indifferent _____
discouraging _____
don't know _____

13. **Based on your experience what are the attitudes of hardware suppliers towards energy saving devices?**

promote the technology _____
indifferent _____
discouraging _____
don't know _____

14. **How would you rate your supplier's knowledge of energy saving devices?**

superior _____
adequate _____
poor _____
don't know _____

15. **What are the attitudes of your mechanical electrical contractors towards energy saving devices?**

promote the technology _____
indifferent _____
discourage _____
don't know _____

APPENDIX E

SURVEY QUESTIONNAIRE - PHOTOFINISHING EQUIPMENT SUPPLIERS

PHOTO-FINISHING EQUIPMENT

MANUFACTURERS/REPRESENTATIVES QUESTIONNAIRE

1. COMPANY STATISTICS

NAME

ADDRESS

CITY

PROVINCE

MANUFACTURER _____ REPRESENTATIVE _____

CONFIRM COMPANIES _____

& EQUIPMENT SOLD _____

CONFIRM LOCATION _____

_____

_____

2. VOLUME OF SALES

	$ 1983	# of installations	Total sold to date
Conventional Equip.	_____	_____	_____
1 hour Equip.	_____	_____	_____
System servicing	_____	_____	_____

SECTION A.

1. When promoting your product, is any consideration given to its energy consumption characteristics?

_____

2. Are you familiar with heat pump technology?

_____

3. Are you aware of the energy saving potential using heat pumps in photo processing?

_____

4. In your opinion is there a future in Canada for applications of heat pump technology in the photo processing industry?

_____

5. As an equipment vendor would you be interested in promoting heat pump technology with your equipment?

_____

6. What type of incentive would make promotion more effective?

_____

SECTION B. MARKET INFORMATION

1. In photo finishing what percentage of total film processed is processed by conventional labs? By 1 hr. labs (Note: one estimate is 75-25)?

2. There are no reliable data available on the film processing industry in Canada. It is estimated that approximately $225,000,000 was spent, in 1983 on film processing across Canada. Is this a reasonable estimate?

3. It is estimated that approximately $1 billion was spent on photographic equipment of all types in 1983. Is this a reasonable estimate?

4. What growth rate in system sales are you forecasting over the next five years?

5. What is your estimated market share now?

6. Do you expect it to increase based on the forecast growth in sales?

7. Do you foresee any structural changes in the photo finishing industry?

   - o market share shift to one hour finishing
   - o fewer, larger labs

APPENDIX F

ALTERNATIVE DEVELOPMENT METHODOLOGIES FOR THE SIZE OF THE CANADIAN PHOTOFINISHING SECTOR

ASSUMPTIONS AND RELATIONSHIPS USED TO DEVELOP MARKET SIZE ESTIMATES

1. The Canadian population is approximately 10% of the American population; there is no apparent difference between the American and Canadian photo-finishing consumer.

2. Photo-finishing represents approximately 17% of the GNPP in the U.S. In 1972 the relationship was 20%. The lower figure (17%) can be applied to the Canadian GNPP to provide a conservative estimate of Canadian sales.

3. The historic growth rate in exposures and expenditures on photographic equipment and supplies is 8 - 10%. An average of the lower rate can be used with a known relationship of disposable income to photographic sales.

4. In 1979 1 billion exposures were made in the U.S.A. at a cost of $2.1 billion in finishing, approximately 20¢/exposure.

5. In 1979 in the U.S.A. approximately 130 pictures were taken per household at a cost of $18.20 per annum per household. A comparable estimate made for Canada is somewhat lower - $12.65. The total per household expenditures in the two countries in 1979 were $85 (USA) and $62.40 in Canada.

6. The percentage increase in expenditures on photographic equipment is related directly to the percentage increase in disposable income.

7. The percentage increase in expenditures on services is related directly to the expenditure increase on photo finishing.

The following tables develop 1980 figures for Canadian photo-processing sales from these relationships.

LIST OF TABLES

TABLE	METHOD
1	Application of 10% Approximation (based on population)
2	Application of American-based Ratios Relating GNP to GNPP and Dollars Spent on Photo-finishing
3	Extension of Pictures/Household Data
4	Application of Disposable Income Relationships to 1972 Survey Data
5	Application of Expenditure on Service Relationships to 1972 Survey Data

TABLE 1
THE CANADIAN PHOTO-FINISHING SECTOR
(by applying the 10% approximation)

	U.S.A.			CANADA*		
YEAR	G.N.P. ($trillion)	GNPP** ($billion)	PHOTO-FINISHING ($ billion)	G.N.P. ($billion)	GNPP** ($million)	PHOTO-FINISHING ($million)
1972	1.1	4.8	1.2	116	480	120
1979	2.4	12.8	2.1	240	1,280	210
1980	2.6	14.4	2.3	260	1,440	230*
1981	2.9	15.1	2.4	290	1,500	240
1982	-	15.8	2.7**	-	1,580	270

* Maclean-Hunter Research Bureau, Canada's Photography Market 1980 estimated the 1980 GNPP and photo-finishing volume of sales at over one billion and approximately $150 M respectively.

** Photo Marketing Association International estimated 1982 at $3.2 billion with a 10% growth for 1983.

TABLE 2a
THE AMERICAN PHOTO-FINISHING SECTOR
DEVELOPMENT OF RATIOS

YEAR	G.N.P. ($trillion)	GNPP ($billion)	PHOTO-FINISHING ($ billion)	GNPP/ GNP	FINISHING/ GNP	FINISHING/ GNPP
1972	1.16	4.8	1.2	4.1	1.0	2.5
1979	2.4	12.8	2.1	5.3	.9	1.6
1980	2.6	14.4	2.3	5.5	.9	1.6
1981	2.9	15.0	2.4	5.2	.8	1.6
1982	-	15.8	2.7	-	-	1.7

TABLE 2b
THE CANADIAN PHOTO-FINISHING SECTOR
(by application of the American Ratios)

YEAR	G.N.P. ($billion)	GNPP ($million)	PHOTO-FINISHING ($ million)
1972	110	456	98
1979	277	1,468	249
1980	311	1,710	280
1981	350	1,820	280
1982	362	-	

---

* actual survey values from Canadian Photographic Magazine.

TABLE 3
CANADIAN PHOTO-FINISHING INDUSTRY
(by extension of pictures/household data)

CPI	YEAR	HOUSEHOLDS (millions)	PICTURES/ HOUSEHOLD	COST/ PICTURE	VALUE OF PHOTO FINISHING
155.5	1978	7.8	-	20¢	-
169.7	1979	8.6	130	20¢	233.6
186.9	1980	8.9	141	22¢	276.1

TABLE 4
CANADIAN PHOTO-FINISHING SECTOR
(application of Disposable Income Relationships)

YEAR	DISPOSABLE INCOME (% Increase)	EXPENDITURES ON PHOTO EQUIP. (% Increase)	VALUE OF EQUIP. ($ millions)	EXPENDITURES FINISHING ($ millions)
1972*			456.4	97.5
1973/72	5	14	519.8	111.2
1974/73	5	14	592.6	126.7
1975/74	5	14	675.5	144.5
1976/75	4	12	756.6	161.8
1977/76	3	8	817.1	174.7
1978/77	4	12	915.2	195.7
1979/78	3	8	988.4	211.4
1980/79	2	6	1,047.7	224.0
1981/80	3	8	1,131.5	242.0
1982/81	(2)	(6)	1,063.6	232.3
1983/82				
			Average 8.8%	

* actual figures from Canadian Photographic Magazine.

TABLE 5
CANADIAN PHOTO-FINISHING SECTOR
(by application of Expenditure on Service Relationships)

YEAR	EXPENDITURE ON SERVICES INCREASE (percent)	EXPENDITURE ON PHOTO-FINISHING ($ millions)
1972	-	97.5*
1973	5	102.4
1974	5	107.5
1975	5	112.9
1976	4	117.4
1977	3	120.9
1978	4	125.7
1979	3	129.5
1980	2	132.1
1981	3	136.1
1982	(2)	133.4

(Not consistent with 8 - 10% average increase in photo-finishing expenditures)

* actual 1972 values from Canadian Photographic Magazine.

APPENDIX G

WATER SUPPLY AND WASTE WATER CONDITIONS FOR A TYPICAL OPERATING DAY AT SNAPPERS

time hour	fresh water temp. (C)	hot water temp. (C)	waste water temp. (C)	waste water flow L/min
8.511	14.979	59.972	28.102	27.842
8.543	15.000	59.886	28.430	27.842
8.576	15.031	59.959	29.797	27.842
8.608	15.073	59.896	28.490	27.842
8.641	15.068	59.766	29.189	27.842
8.674	15.126	59.861	26.286	27.842
8.708	15.142	60.326	26.192	27.842
8.742	15.225	61.162	27.031	27.842
8.775	15.256	61.414	26.976	27.842
8.809	15.251	61.275	26.622	27.842
8.843	15.231	60.943	29.296	27.842
8.877	15.273	60.553	30.166	27.842
8.911	15.253	60.355	28.946	27.842
8.945	15.284.	60.540	29.757	27.842
8.981	15.290	60.792	30.291	27.842
9.016	15.270	60.392	29.036	27.842
9.051	15.301	60.465	29.784	27.842
9.086	15.333	60.380	30.322	27.842
9.121	15.338	60.385	29.028	27.842
9.156	15.385	60.628	29.518	27.842
9.192	15.391	60.790	30.412	27.842
9.228	15.397	60.503	29.148	27.842
9.266	15.417	60.454	29.425	27.842
9.302	15.423	60.098	30.418	27.842
9.338	15.418	59.824	29.500	27.842
9.374	15.424	59.919	29.223	27.842
9.411	15.430	60.252	29.822	27.842
9.448	15.414	60.338	30.632	27.842
9.485	15.420	60.289	29.121	27.842
9.522	15.415	60.001	29.413	27.842
9.561	15.436	59.726	30.603	27.842
9.599	15.457	59.745	29.379	27.842
9.636	15.452	59.876	29.211	27.842
9.674	15.484	59.669	29.963	27.842
9.712	15.468	59.484	29.983	27.842
9.750	15.464	59.209	29.138	27.842
9.789	15.459	59.272	29.430	27.842
9.827	15.480	59.471	30.462	27.842
9.868	15.449	59.684	29.742	27.842
9.907	15.460	59.341	29.070	27.842
9.946	15.481	59.111	29.303	27.842
9.985	15.491	58.396	30.508	27.842
10.024	15.486	58.541	29.590	27.842
10.064	15.482	58.931	29.066	27.842
10.104	15.492	59.211	29.398	27.842
10.144	15.487	59.175	30.371	27.842
10.186	15.498	58.855	29.813	27.842
10.227	15.493	58.502	29.092	27.842
10.267	15.478	58.543	28.829	27.842
10.308	15.473	59.050	30.209	27.842
10.349	15.457	58.752	30.071	27.842

time hour	fresh water temp. (C)	hot water temp. (C)	waste water temp. (C)	waste water flow L/min
10.389	15.453	58.240	29.315	27.842
10.431	15.412	58.272	29.113	27.842
10.473	15.433	58.562	29.553	27.842
10.516	15.443	58.820	30.575	27.842
10.558	15.428	58.793	29.821	27.842
10.599	15.438	58.441	28.990	27.842
10.641	15.423	58.020	29.173	27.842
10.684	15.382	57.870	29.515	27.842
10.726	15.429	58.206	30.660	27.842
10.769	15.413	58.545	29.189	27.842
10.812	15.347	58.337	29.050	27.842
10.856	15.331	58.279	29.293	27.842
10.900	15.378	58.061	30.365	27.842
10.943	15.389	58.274	30.178	27.842
10.986	15.347	58.148	28.952	27.842
11.030	15.358	57.908	29.036	27.842
11.074	15.332	57.817	29.259	27.842
11.118	15.281	58.008	29.937	27.842
11.163	15.291	58.166	30.233	27.842
11.208	15.302	58.606	29.502	27.842
11.253	15.286	58.103	29.017	27.842
11.298	15.245	57.786	29.027	27.842
11.343	15.256	57.668	29.161	27.842
11.388	15.240	57.940	29.690	27.842
11.433	15.225	58.231	30.416	27.842
11.479	15.210	58.389	30.007	27.842
11.524	15.246	57.991	29.152	27.842
11.572	15.220	57.887	28.855	27.842
11.572	15.220	57.887	28.855	27.842
11.618	15.231	58.123	28.989	27.842
11.664	15.231	57.964	29.147	27.842
11.710	15.190	57.646	29.370	27.842
11.757	15.164	57.588	30.407	27.842
11.803	15.149	58.118	30.491	27.842
11.850	15.159	58.594	30.008	27.842
11.898	15.170	58.060	29.252	27.842
11.946	15.144	57.729	28.890	27.842
11.994	15.129	57.398	28.950	27.842
12.042	15.113	57.693	29.099	27.842
12.089	15.098	57.838	29.455	27.842
12.137	15.057	58.232	29.910	27.842
12.185	15.067	57.652	30.561	27.842
12.234	15.016	57.698	29.821	27.842
12.282	15.042	58.092	29.040	27.842
12.333	15.000	57.775	28.792	27.842
12.382	15.000	57.308	28.966	27.842
12.431	14.985	57.467	29.050	27.842
12.480	15.011	58.247	29.258	27.842
13.034	14.971	57.431	29.753	27.842
13.086	14.945	57.531	30.455	27.842
13.139	14.945	57.894	27.955	27.842

time hour	fresh water temp. (C)	hot water temp. (C)	waste water temp. (C)	waste water flow L/min
13.191	14.930	58.719	26.511	27.842
13.243	14.852	58.719	28.551	27.842
13.294	14.800	57.495	28.774	27.842
13.346	14.811	57.268	28.908	27.842
13.399	14.785	57.541	28.858	27.842
13.451	14.759	57.663	29.180	27.842
13.504	14.770	57.663	29.116	27.842
13.034	14.971	57.431	29.753	27.842
13.086	14.945	57.531	30.455	27.842
13.139	14.945	57.894	27.955	27.842
13.191	14.930	58.719	26.511	27.842
13.243	14.852	58.719	28.551	27.842
13.294	14.800	57.495	28.774	27.842
13.346	14.811	57.268	28.908	27.842
13.399	14.785	57.541	28.858	27.842
13.451	14.759	57.663	29.180	27.842
13.504	14.770	57.663	29.116	27.842
13.559	14.791	57.500	29.349	27.842
13.612	14.817	57.940	29.260	27.842
13.665	14.894	57.659	29.878	27.842
13.719	14.931	57.396	30.406	27.842
13.772	14.967	57.496	30.258	27.842
13.826	14.941	58.176	30.095	27.842
13.880	14.915	58.049	29.132	27.842
13.934	14.926	57.628	28.795	27.842
13.990	14.885	57.287	28.805	27.842
14.045	14.833	57.660	28.904	27.842
14.100	14.859	57.696	28.978	27.842
14.154	14.818	57.683	29.137	27.842
14.209	14.777	57.624	29.122	27.842
14.265	14.802	58.122	28.999	27.842
14.320	14.802	57.805	28.850	27.842
14.376	14.802	57.329	28.825	27.842
14.433	14.751	57.442	28.899	27.842
14.489	14.725	58.213	28.850	27.842
14.546	14.761	57.973	26.598	27.842
14.602	14.710	58.200	26.348	27.842
14.658	14.684	57.529	29.167	27.842
14.715	14.643	57.483	29.365	27.842
14.772	14.617	57.606	29.167	27.842
14.829	14.617	57.597	29.390	27.842
14.887	14.694	57.370	29.340	27.842
14.945	14.710	57.860	29.281	27.842
15.003	14.710	57.633	29.642	27.842
15.060	14.684	57.111	29.677	27.842
15.118	14.668	57.483	30.244	27.842
15.176	14.606	58.050	30.452	27.842
15.234	14.601	57.719	30.289	27.842
15.293	14.524	57.220	30.610	27.842
15.353	14.509	57.479	30.201	27.842
15.412	14.483	57.706	30.127	27.842

time hour	fresh water temp. (C)	hot water temp. (C)	waste water temp. (C)	waste water flow L/min
15.471	14.483	57.661	30.373	27.842
15.530	14.524	57.515	29.697	27.842
15.589	14.565	57.869	29.934	27.842
15.649	14.643	57.665	30.047	27.842
15.708	14.710	57.234	30.269	27.842
15.768	14.710	57.665	30.590	27.842
15.830	14.710	57.937	29.627	27.842
15.891	14.720	58.096	28.126	27.842
15.951	14.694	57.856	27.938	27.842
16.011	14.653	58.159	28.434	27.842
16.072	14.612	58.159	28.508	27.842
16.133	14.534	57.978	28.246	27.842
16.194	14.472	57.434	28.335	27.842
16.255	14.369	56.970	30.378	27.842
16.318	14.332	57.493	30.575	27.842

APPENDIX H

PHOTOFINISHING SALES AT SNAPPER PHOTO LTD.

Thursday May 31, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp		
110-24 exp		
110-36 exp		
126-12 exp		
126-24 exp		
126-36 exp		
135-12 exp		
135-24 exp		
135-36 exp		
Disk		
Reprints		
Total	35	

Saturday, June 2, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp		
110-24 exp		
110-36 exp		
126-12 exp		
126-24 exp		
126-36 exp		
135-12 exp		
135-24 exp	2	47
135-36 exp	3	101
Disk		
Reprints		
Total	5	148

Monday, June 4, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp	3	35
110-24 exp	16	377
110-36 exp		
126-12 exp	3	51
126-24 exp	2	47
126-36 exp		
135-12 exp	7	93
135-24 exp	30	638
135-36 exp	12	404
Disk	9	126
Reprints		4
Total	82	1775

Wednesday, June 6, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp	3	47
110-24 exp	2	50
110-36 exp		
126-12 exp		
126-24 exp		
126-36 exp		
135-12 exp		
135-24 exp	20	461
135-36 exp	1	38
Disk	3	67
Reprints		175
Total	29	838

Friday, June 8, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp	3	29
110-24 exp	2	23
110-36 exp		
126-12 exp		
126-24 exp		
126-36 exp		
135-12 exp	2	25
135-24 exp	10	245
135-36 exp	2	11
Disk	4	72
Reprints		48
Total	23	453

Tuesday, June 12, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp		
110-24 exp	5	112
110-36 exp		
126-12 exp	1	111
126-24 exp	2	
126-36 exp		
135-12 exp	6	48
135-24 exp	24	765
135-36 exp	7	256
Disk	4	95
Reprints		250
Total	49	1537

Thursday, June 14, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp		
110-24 exp	6	78
110-36 exp		
126-12 exp		
126-24 exp		
126-36 exp		
135-12 exp	5	102
135-24 exp	9	175
135-36 exp	4	174
Disk	4	58
Reprints		67
Total	28	654

Monday, June 18, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp	3	31
110-24 exp	8	202
110-36 exp		
126-12 exp	1	11
126-24 exp		
126-36 exp		
135-12 exp	9	117
135-24 exp	31	866
135-36 exp	10	246
Disk	13	148
Reprints		163
Total	75	1784

Wednesday, June 20, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp	1	9
110-24 exp	2	42
110-36 exp		
126-12 exp	4	42
126-24 exp	4	83
126-36 exp		
135-12 exp	2	38
135-24 exp	17	412
135-36 exp	2	74
Disk	3	60
Reprints		101
Total	35	861

Friday, June 22, 1984

TYPE OF FILM	NUMBER OF FILMS PROCESSED	NUMBER OF PRINTS MADE
110-12 exp	1	12
110-24 exp	2	36
110-36 exp		
126-12 exp	3	37
126-24 exp	2	41
126-36 exp		
135-12 exp	5	60
135-24 exp	17	526
135-36 exp	5	134
Disk	2	29
Reprints		98
Total	37	973